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REFINER
AND NATURAL GASOLINE MANUFACTURER

JUNE, 1933
Vol. 12, No. 6

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REFINER
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VOLUME 12, No. 6 JUNE, 1933

Looking Up

HIGHER tank car prices for gasoline are in prospect. The better foundation of the crude oil market as well as changes in marketing practices of major distributors point to the coming of higher quotations at refining centers.

As this is written many conditions point to a raise in the crude oil price structure. The common result is for higher crude oil prices to bring corresponding higher gasoline prices without giving the manufacturer any wider profit on his goods. But the next raise in the price of crude oil should come along with the movement of crude oil in lines of major buyers equal to field output. In that case there will be none or little of the distress crude which has been the cause of unprofitable refinery prices for some two years. Owners of the temporary skimming plants in flush fields will not be able to get oil below the posted price, therefore they will be forced to sell refinery output at higher levels.

But the more important events of the past month have been changes in marketing policies of two units of the Standard group. Socony-Vacuum Corporation has adopted the method of basing its service station prices on gasoline prices at Gulf ports. Standard Oil Company (Indiana) has reduced margins to dealers and further served notice that dealers must absorb half the loss of any service station local price reductions up to a maximum of one cent a gallon to them.

The discounts announced by the Indiana company plus changes in station rentals will reduce margins to dealers and AAA operators to a maximum of three cents a gallon. This change evidently means that the practice of guaranteeing gross margins of from five cents to six cents a gallon to jobbers is at an end.

Contracts of this type played a major role in driving prices f.o.b. refinery to a low level. The refining company guaranteed an excessive gross profit to the jobber. If the price went down, the jobber still had his gross profit, consequently the price at the refinery suffered. The refinery price carried the full load of price reductions at the service station.

Now the Indiana company proposes that dealers and operators of its AAA stations shall absorb half the loss of local service station price reductions. Thus a dealer would suffer a loss of one cent per gallon, if the price fell off two cents a gallon. Obviously dealers will not be anxious to see price reductions. Contracts, which guaranteed a gross profit to the jobber often were an inducement to price reduction. The retail seller did not care about the retail price when he had a guarantee of gross profit.

It is too early to predict that the trade in general will revise its contracts with jobbers, dealers and operators of leased stations. But indications are that the industry has come to the day when it must accept thin margins at the service station. When such becomes practice the weight that has rested on the refinery market will be lighter.

By basing prices on prices at Gulf ports, Socony-Vacuum Corporation has tied its retail price structure to something stable. While there is fluctuation in the Gulf coast market, it does not move rapidly and drastically as does the price at interior refining points. A few large concerns determnie the market at Gulf ports. They are in position to hold gasoline, while smaller concerns in the interior must move finished products regardless of price.

For more than a year the refining plants and the natural gasoline plants have shipped gasoline into a market over which there was no control. Lower and lower quotations have been written month after month. Now there is a basis for a rising market.

Added to this is the indication that the consumption of gasoline will surpass estimates made at the meeting of the American Petroleum Institute in May. Figures are not yet available but there is a chance that the end of the year will see consumption even with last year.

DEVELOPMENTS IN

Naphtha-Reforming Practice

for Octane-Number Improvement

E. J. LeROI and H. W. FERGUSON
Humble Oil & Refining Company, Baytown, Texas

NAPHTHA reforming is a direct outgrowth of the ever-increasing demand for higher-octane-number motor fuels. Since the refiner has been dependent in the past on selection of crudes and blending fluids for anti-knock improvement, the application of naphtha cracking lends greater flexibility to refinery operation. It is essential, however, that the reforming process be studied throughout a wide range of octane-number improvement in order that the most economical point of operation be determined. The experimental work, upon which the following discussion has been based, is the result of three years of plant operation on both straight-run and cracked heavy naphthas. The combined and individual effects of time, temperature, and type of feed stock on yield, capacity, and product quality have been carefully analyzed for varying degrees of octane-number improvement.

TULSA, OKLAHOMA · MAY 17-19, 1933

THE straight-run charge stocks used in the experimental work represents a mixture of cuts from Panhandle, Reagan, Salt Flat, Coastal, Northeast Texas, and Humble—West Texas crudes. The cracked stock was obtained by distillation of a heavy naphtha withdrawn from units cracking a mixed heavy gas oil derived from the above crudes. The characteristics of average samples of the charge stocks are indicated in Table 1.

Since the experimental work was spread over such long periods of time, complete analyses of the feed stocks were procured whenever possible in order to eliminate data on widely different heavy naphthas. The straight-run naphthas processed in the first re-cycle runs were a broader cut stock than those charged in the later re-cycle and once-through runs. Only a slight variation in aniline point was observed on this stock (132°F. to 138°F.) in all runs made. The octane numbers ranged from 30 to 32 in most tests, with the exception of the last five coil-only runs, which showed 30- to 38-octane-number feed stocks. The cracked heavy naphthas were of uniform composition in all test runs. The octane-number determinations on both charge stocks were obtained by direct comparison with *iso*-octane and normal heptane mixtures. These octane numbers were procured on a Series 30 engine.

Eight series of runs were made—five on the straight-run stock and three on the cracked heavy naphtha, with operating conditions as indicated in Table 2.

In Series 1 and 2 the octane-number improvement was obtained by under-cutting the end-point of the cracked distillate. The improvement was obtained in the other series by adjustment of coil-outlet temperature and/or feed rate. All operations were at 800 pounds pressure, except in Series 8 in which the pressure was at 250 pounds per square inch.

The description of equipment can be accomplished to the best advantage with the aid of flow diagrams. The units used in the experimental work were of the

TABLE 1
Average Inspections of Charge Stocks

	Straight-Run Heavy Naphtha	Cracked Heavy Naphtha
Distillation range in degrees F.:		
Gravity, deg. A.P.I.	5.10	45.0
Initial boiling point	230	260
End point	415	415
Percentage at 400	96.0	97.0
10 per cent point	275	310
50 per cent point	315	340
90 per cent point	370	375
Aniline point, deg. F.	132	112
Octane No.	31	52

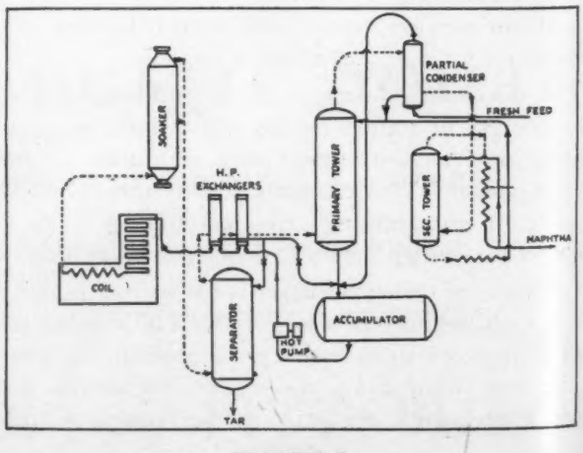


FIGURE 1
Re-cycle Flow

TABLE 2
Types of Operation

1. Re-cycling straight-run heavy naphtha with coil and soaker at 940°F. coil-outlet temperature.
2. Re-cycling cracked heavy naphtha with coil and soaker at 924 to 930°F. coil-outlet temperature.
3. Re-cycling straight-run heavy naphtha with coil and soaker at 940 to 970°F. coil-outlet temperature.
4. Once-through on straight-run heavy naphtha with coil and soaker at 917 to 995°F. coil-outlet temperature.
5. Once-through on cracked heavy naphtha with coil and soaker at 945°F. coil-outlet temperature.
6. Once-through on straight-run heavy naphtha, with coil only, at 980 to 1,020°F. coil-outlet temperature.
7. Once-through on cracked heavy naphtha with coil only, at 995 to 1,025°F. coil-outlet temperature.
8. Once-through on straight-run heavy naphtha, with coil only, at 1,020°F. coil-outlet temperature and reduced pressure.

tube-and-tank type, equipped with a furnace capable of a heat input of the oil of 28 million B.t.u. per hour.

Figure 1 shows the flow in a normal re-cycle operation in which the fresh feed is pre-heated in a partial vapor condenser and pumped to the accumulator, where the cycle oil from the primary tower joins it to make up the total feed stream. Hot pumps force the total through high-pressure exchangers, the coil, and the up-flow soaker (operating at 800 pounds per square inch.) Pressure is released at the soaker outlet, and the cracked stock flashes in the separator—where tar is removed from the bottom. The overhead vapors pass through the high-pressure exchangers and fractionating equipment. Naphtha of the desired end point is partially condensed in a vapor to feed exchanger, and passes through the final cooler to the receiving drum.

The once-through operation in Figure 2 differs from the first hook-up in that no cycle fractions join the food to the coil. A small stream of cycle oil from the bottom of the primary tower is withdrawn, cooled, and fluxed to the soaker outlet—which is equipped with a coke drill. The drilling and cooling action at the point of release is essential to satisfactory operation at the higher temperatures. No attempt is made to fractionate the distillate. In both operations tar flux is admitted to the separator to control gravity.

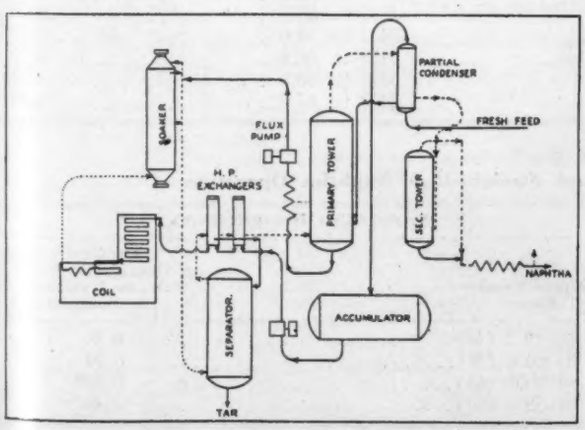


FIGURE 2
Once-through Flow

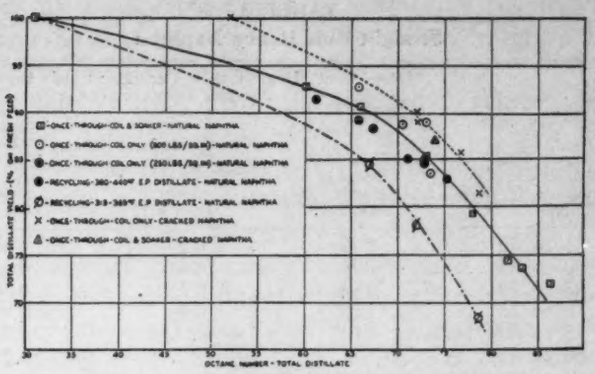


FIGURE 3
Heavy-Naphtha Cracking Yield Octane-Number Relationship—Total Distillate

The relationship between total distillate yield and octane number for the re-cycling and once-through operations on both straight-run and cracked naphthas is shown graphically in Figure 3. In determining the yields, all liquid quantities were obtained from tank gages, and gas figures from meter readings. A butane recovery of 80 per cent was used in calculating the casinghead content of the wet gases.

In order to discuss the yield relationships between operations on a comparable basis, all distillate quantities were corrected to a 400°F. naphtha in all cases where the end point exceeded 400°F. A yield of 60 per cent was assumed on re-cracking the diesel fraction. Table 3 gives a clear picture of the degradation of the original charge stock to gas and tar for the several types of operation.

The data in Table 3 show clearly the decrease in degradation obtained by the once-through operation and the re-cycle operation to 400°F.-end-point naphtha as compared to the re-cycle operation in which octane-number improvement was obtained by undercutting end point. The degradation per point of octane-number improvement in Series 3 and 4 is about the same in the range investigated. The once-through operation is more feasible in a case where a 420°F-end-point finished gasoline is required, since the quantity between 420°F. and the end point is but 2 per cent to 4 per cent, and furnishes an excellent re-run bottom.

The coil-only once-through runs were made to determine whether or not the decreased time at higher temperatures would lessen degradation. The effect of pressure on cracking conditions was also investigated. Table 4 gives the comparison. The degradation per point of octane-number improvement is about the same in the coil-only runs at 800 pounds as was realized with the coil and soaker. Operation at 250 pounds showed a definite tendency toward in-

TABLE 3
Straight-Run Heavy Naphtha

Octane-Number Range	Per Cent Degradation Per Point of Octane-Number Improvement: Series 1 (Re-cycle at 940 Deg. F.)	Series 3 (Re-cycle at 940 to 970 Deg. F.)	Series 4 (Once-Through at 917 to 995 Deg. F.)
31 to 60	0.39	0.29	0.30
60 to 65	0.56	0.44	0.42
65 to 70	0.98	0.70	0.68
70 to 75	1.38	0.90	0.90
75 to 80	1.61*	...	1.12
80 to 85	...	...	1.28

* Based on 75.0 to 78.6 octane-number range.

creased degradation. This point has also been observed in research work by other companies.

A comparison is made in Table 5 between the cracked and straight-run heavy naphthas on the basis of the same over-all octane-number improvement. In the range indicated straight-run-naphtha cracking results in a much lower degradation loss. However, for the range of 75 to 80 octane number, in the once-through runs, the degradation for both types of heavy naphtha is about the same. A compensating factor for the higher degradation realized in the cracking of cracked naphthas, as compared to cracking straight-run naphtha, lies in the fact that no additional treating costs are incurred in the former procedure, as the cracked naphtha has to be treated in any event.

So far in the discussion comparisons between operations have been based principally upon degradation. Unit capacity and product quality should also be considered.

Table 6 points out the capacity advantage of the once-through coil-and-soaker flows at 800 pounds

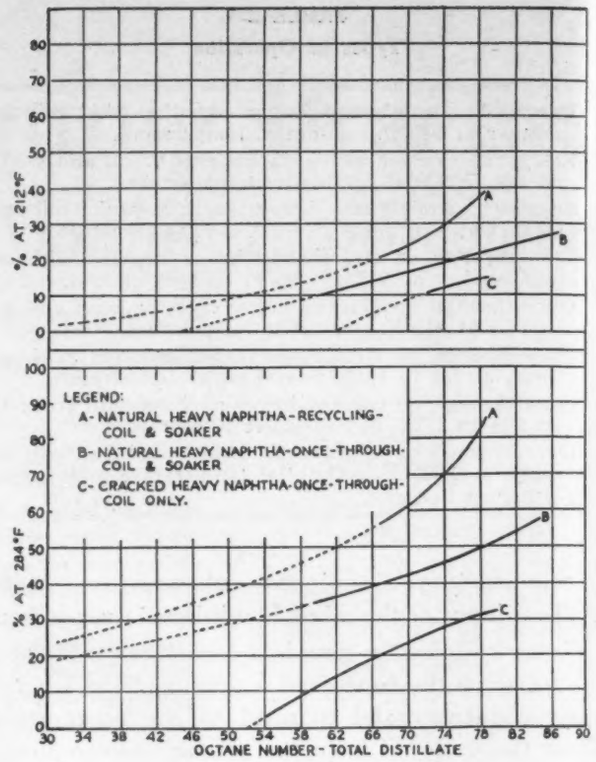

% AT 212°F
% AT 284°F
LEGEND:
A- NATURAL HEAVY NAPHTHA-RECYCLING-COIL & SOAKER
B- NATURAL HEAVY NAPHTHA-ONCE-THROUGH-COIL & SOAKER
C- CRACKED HEAVY NAPHTHA-ONCE-THROUGH-COIL ONLY.
OCTANE NUMBER - TOTAL DISTILLATE

FIGURE 4
Heavy-Naphtha Cracking Change in Volatility of Total Distillate with Increased Octane Number

pressure over the other types of operation on straight-run stock. Of the two coil-only flows, the high-pressure operation is considerably better from the standpoint of feed rate. The re-cycle operations are all lower in capacity. The same observations hold true for the cracked stocks. The foregoing conclusions are based on the use of existing equipment for naphtha-reforming service. In the design of new

TABLE 4
Comparison of Degradation for Coil-Only and Coil-Soaker Operation on Straight-Run Heavy Naphtha

Coil-Only Straight-Run Naphtha: Octane-Number Range	Per Cent Degradation Per Octane-Number Improvement	Coil-and-Soaker Straight-Run Naphtha: Octane-Number Range	Per Cent Degradation Per Octane-Number Improvement
31.0 to 73.0 (800 lb.)	0.32	31.0 to 73.0	0.40
36.0 to 70.5 (800 lb.)	0.40	31.0 to 65.5	0.33
38.2 to 65.8 (800 lb.)	0.29	31.0 to 58.6	0.30
37.7 to 73.5 (800 lb.)	0.48	31.0 to 66.8	0.34
36.0 to 65.8 (250 lb.)	0.44	31.0 to 60.8	0.31
36.6 to 72.8 (250 lb.)	0.43	31.0 to 67.2	0.35

TABLE 5
Comparison of Degradation on Cracked and Straight-Run Naphtha Operation

Cracked Heavy Naphtha: Octane-Number Range	Per Cent Degradation Per Octane-Number Improvement	Straight-Run Heavy Naphtha: Octane-Number Range	Per Cent Degradation Per Octane-Number Improvement
52.0 to 80.2 (R)	1.21	31 to 59.2 (R)	0.38
52.0 to 81.8 (R)	1.42	31 to 60.6 (R)	0.39
52.0 to 70.0 (O)	0.59	31 to 49.0 (O)	0.29*
52.0 to 80.0 (O)	0.76	31 to 59 (O)	0.30

(R) Re-cycle operation under-cutting end point.
(O) Once-through operation.
*Extrapolated.

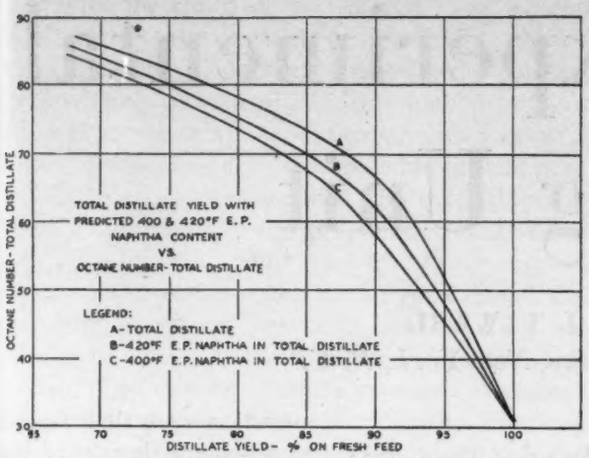


FIGURE 5

Heavy-Naphtha Cracking Distillate from Natural Heavy Naphtha Once-through Coil-and-Soaker Operation.

equipment, a coil-only high-pressure flow would more than likely be more feasible, since it eliminates the expense of a soaker installation.

The characteristics of the total distillates produced in the several types of operation are presented graphically in Fig. 4.

The fills of the total naphtha at 212°F. and 284°F. are given for the once-through coil-and-soaker operation on straight-run heavy naphtha at 800 pounds, the re-cycle under-cutting operation on straight-run naphtha, and once-through coil-only flow on cracked heavy naphtha at 800 pounds pressure.

The coil-only data on the natural stock and the coil-and-soaker data on the cracked-naphtha operation were in close agreement with the aforementioned results; and, therefore, are not included. The re-cycling operation in which octane number was obtained by under-cutting end point resulted in a naphtha of much greater volatility. For example, the fill of a 70-octane-number naphtha in Series 3 and 4 was approximately 16 per cent, as compared to 24 per cent when re-cycling. The only possible economical application of the latter operation would be to a refinery situation in which volatility is at a premium.

Butane production from naphtha cracking increases with the degree of octane-number improvement. This production can be absorbed in the gasoline up to a certain point, after which the butane must be discarded as fuel. No arbitrary figure for butane inclusion in the gasoline can be set, since it depends entirely upon the individual refinery situation.

As has been pointed out previously, no attempt was made to fractionate the distillate from the once-through operation to a specified end point. In Fig. 5 the naphtha yields, after re-running to 400°F. and 420°F. end point, are plotted against the octane number of the total distillate. This comparison is for coil-and-soaker once-through cracking of straight-run stocks. A maximum loss of 4 per cent on fresh feed occurs when re-running to 420°F., and 8 per cent when producing a 400°F. end point by re-distillation.

At this point it may be well to discuss briefly the limitations to operation which were encountered in the experimental work. All the runs were made at maximum furnace capacity. The re-cycle operation on the natural stock in the 940- to 970°F. temperature range presented no operating difficulties. Similar operation on the cracked stock gave evidence of short runs due to release-nozzle coke trouble. This condition could undoubtedly be overcome by the use of a coke drill.

The once-through coil-and-soaker operation with a coke drill presented no difficulties in the 917- to 980°F. coil-outlet temperature range. Runs of 30 days are not uncommon. Operation with coil-outlet temperature of 980°F. to 995°F. was limited to short runs due to soaker coking. The coil-only flow on straight-run naphtha required high coil-outlet temperatures to secure octane-number improvement. Operation at the higher temperatures was seriously limited by tube-metal temperatures due to the high rates of heat input.

The once-through operations on cracked naphtha were limited to relatively short runs due to coke formation. The coil-only flow was hampered by coil coking, and the coil-and-soaker operation was characterized by frequent drilling of the release nozzle.

Although no attempt has been made in this report to interpret the economic significance of the foregoing results, the yields and operating data presented are considered adequate for an economic analysis of any refinery situation.

TABLE 6
Coil Capacity in Barrels Per Day Vs. Octane Number of Total Distillate

	Straight-Run Heavy Naphtha					Cracked Heavy Naphtha		
Series of Run	1	3	4	6	8	2	5	7
Description	Re-cycling at 940 Deg. F. at 800 lb.	Re-cycling to 400 Deg. F. End Point at 800 lb.	Once-Through Coil-and-Soaker at 800 lb.	Once-Through Coil-Only at 800 lb. (Barrels Per Day)	Once-Through Coil-Only at 250 lb.	Re-cycling at 930 Deg. F. at 800 lb.	Once-Through Coil-and-Soaker at 800 lb.	Once-Through Coil-Only at 800 lb.
Distillate Octane No.								
65	3,100	....	6,250	5,050	4,300	....	....	....
70	2,650	4,000	6,000	4,700	3,600	....	6,100	4,800
75	2,200	....	5,750	4,400	2,800	....	....	4,650
80	1,800	....	5,500	4,000	....	2,150	....	4,500

A Modern Experimental Cracking Unit

W. W. GARY and J. T. WARD
The M. W. Kellogg Company, New York, N. Y.

TULSA, OKLAHOMA AD MAY 17-19, 1933

COMMERCIAL cracking units at the present time produce approximately one half of the supply of all gasoline consumed, and indications are that future requirements from this source will be increased. Methods of cracking vary with the type of existing equipment and the processes used. However, within the limitations of such equipment, considerable variation can be obtained in yields and specifications of products. It is important, therefore, particularly from the standpoint of economy and type of products produced, that operating conditions of the cracking unit be capable of adjustment to the optimum. Unfortunately, optimum conditions of operations are not constant, but are subject to change due to variations in cracking-plant charges and marketing requirements. The fulfillment of the ideal often requires experimental determinations.

Experimentation with commercial-size equipment is generally somewhat handicapped by plant limitations and the necessity for the refiner to maintain certain specific time schedules of production. Also, due to the magnitude of operations, such plant tests are costly compared with results to be obtained from laboratory equipment. A laboratory pilot cracking unit presents the ultimate in desirability for experimental work, provided the data obtainable are representative and sufficiently comprehensive. It may serve three purposes, viz.:

1. *Operating control*—The acquisition of information best to adapt existing commercial equipment to produce the maximum quantities of those products which can be marketed at the greatest profit.

2. *Research*—The development of new and improved methods of processing.

3. *Design*—The establishment of design information for operations on proposed future commercial installations.

Prior to the era of "anti-knock," a cracking plant was appraised principally from the standpoint of yield and cost, and the methods of processing were comparatively confined. Laboratory cracking methods at that time generally consisted of static tests—the equipment comprising bombs, which were charged with the oil in question and heated to a predetermined bomb pressure. The products from this operation were then fractionated—eliminating gas, gasoline, and tar; and the remaining re-cycle fractions were recharged and again subjected to treatment. When commercially operating at high pressures and moderate temperatures, where yields were the only consideration, this method of procedure yielded data for rough approximations through extrapolation to ultimate products. But, as refining methods progressed and the production of anti-knock gasoline became a subject of prime importance, these crude methods were found to be very misleading and even non-indicative of plant-scale results.

It was soon found that development of new laboratory apparatus was necessary, and that laboratory equipment—to be a reliable source of information—must necessarily involve the use of continuously-operating miniature pilot plants which duplicate as closely as possible the essential conditions maintained in a large commercial unit; i.e., pressures, soaking times, temperatures, and fractionation.

Laboratory experimental cracking units were built by certain of the oil refining companies; but little information as to their construction, or regarding the reliability of the results obtained, became available. As a manufacturer and builder of cracking equipment, The M. W. Kellogg Company, at an early date found it desirable and necessary to develop pilot plants in which all of the required cracking operations could be carried out in a representative manner. During this period The Texas Company made available its experience with an autoclave type of pilot plant. The Standard Oil Company of Indiana developed a continuous-flow laboratory unit, certain features of which were adopted by the Kellogg company and contributed materially to the success of this type of apparatus. Certain of these ideas and many developed by The M. W. Kellogg Company from preceding models have been combined in the design and operation of the pilot plants herein described.

WHAT CAN BE ACCOMPLISHED

The laboratory of the Kellogg company has two complete miniature plants. Each of these units has been continually and progressively changed: first,

to cope with the trend of the industry; and, second, to incorporate features resulting from field and laboratory research. A degree of refinement has been reached wherein practically all commercial types of cracking processes may be duplicated with a range of flexibility even surpassing that possible in field practice. The units produce finished products which are constantly controlled to the proper specifications.

Each pilot cracking plant consists of four separate cracking zones. These zones are so constructed that temperature gradients, pressures, and reacting volumes may be varied to meet arbitrary requirements. All zones, if so desired, may be operated simultaneously—permitting, for example, viscosity breaking, naphtha reforming, vapor-phase and high-pressure cracking as concurrent operations. When a multiplicity of streams is in operation, the proper re-cycle charges are fractionated within the tower equipment, and are continuously returned to their optimum cracking zones.

Researches on "combination" cracking have been possible on these pilot plants—establishing ultimate yields, time-temperature relationships, and product characteristics (including anti-knock). Comparable results would have been impossible by separate operations, due to the fact that the various furnace charging stocks for a given cracking zone may have continuous source from products of any or all other cracking zones, such stocks being in definite proportion to a given virgin charge.

A feature of the equipment includes a continuous stabilizer for the gasoline produced. Efforts of stabilization on ultimate gasoline yields and octane value can be accurately determined, together with changes in gasoline volatility under varying cracking conditions. Volatility has recently become of more importance in the industry owing to the winter and summer grades of commercial gasolines which are marketed.

Tar specifications are also an item of control. It is occasionally desirable for a refiner to produce a high-melting-point pitch during certain periods of marketing conditions to decrease the yields of low-value products. When so doing, the effects on plant capacities, coking characteristics of charge, and anti-knock value of product govern the degree of such variation from normal practices. On the other hand, it may be desirable for the refiner to control the cracking conditions to permit the manufacture of fuel oil of the lowest economical pour test; and, by research on the pilot plant, optimum conditions can be determined for producing the most salable products from any given charge. Thus, the pilot plant plays an important part in predicting operations on unknown stocks, and its operation must be sufficiently flexible to meet widely different operating conditions.

It might at first be concluded that "multiple-stream operation" would not permit inspection of the products from the separate zones. However, this is not the case. Adequate intermediate-point sampling devices are provided; so that the individual charges and products may be examined at will, and the proper processing control maintained.

Generally speaking, laboratory experimental equipment, especially at high temperatures, is subject to greater radiation-heat losses than are encountered in plant experience. When fractionation and liquid-vapor equilibrium conditions are of importance, such as in a cracking plant, special precautions are necessary to prevent these heat losses in small equipment. For this reason the pilot plants are equipped with electrical windings for adiabatic control, and in all cracking zones skin temperatures are observed and recorded. This was found necessary particularly with operations involving soaking drums, where normal plant heat losses must be paralleled in experimental equipment more correctly to duplicate soaking conditions. Additional control is afforded by the use of electrical heating units in the cracking zones. Records of the power inputs to these zones have greatly increased existing knowledge of "heats of cracking."

The flexibility of these pilot plants may be visualized from the range of operating conditions afforded. The units are capable of pressures from atmospheric to 5000 pounds per square inch. Temperatures as high as 1250°F. can be maintained with special additional provisions for going to 1600°F. on particular apparatus. Soaking times are practically unlimited, permitting cracking times of from a fraction of a second to as high as 30 minutes. When operation is to be accomplished by coil and drum, chambers of any desired dimensions and volumes may be installed.

A plot plan of one of the pilot cracking units is shown in Figure 1. An important feature considered in the original layout of this unit was the arrangement of equipment to permit access to all parts, and yet provide for short transfer lines from the cracking zones to the tower equipment. This is shown by the centralizing of zone outlets close to the evaporator, whether from drums or coils.

The fresh-feed and re-cycle-charge tanks, **1**, are positioned at a proper elevation upon a platform. This elevated position provides for adequate pump suction and easier observation by the still operators. The bottom outlets from these charge tanks lead to separate charging pumps of variable capacity. All pump discharges are piped to a centralized point, indicated in the figure by **2**. From this point the charge lines lead to each of the numerous cracking zones. This arrangement permits changing the flow from any charge tank to any cracking zone merely by providing the proper jump-over connection.

Each cracking-zone inlet leads from a gas-fired preheater which discharges into the main cracking coils. These preheaters heat the incoming charges

to temperatures up to 800°F. or less. The preheater coils which are made of three eighths-inch inside diameter extra heavy tubing are immersed in circular lead baths to avoid over-heating and provide uniform heat application.

The cracking coils for the various zones consist of a series of sections, each section being provided with a separate lead bath. The lead baths are individually heated and heavily lagged. Each bath is provided with thermocouples for both the oil and the lead. The coils vary in diameter from one sixteenth-inch to three eighths-inch inside diameter, and are of steel or alloy tubing. Several coils of different dimensions are installed in each zone, allowing a selection of volume capacity per unit temperature gradient. All coils are accurately calibrated for volumes, and temperature curves have been established for each section under widely different operating conditions.

Temperatures of the baths are maintained electrically with immersion heaters controlled by rheostats, centralized on the operating panel board. The oil undergoing cracking is heated according to a desired temperature gradient with the proper volume relationships as provided or proposed in an existing or contemplated commercial unit.

The electrical energy required for temperature maintenance is recorded for each bath which, when properly evaluated against blank determinations, yields information on total heats and heats of cracking.

Zones **3** and **4** are employed for coil cracking, while zones **5** and **6** are provided with soaking drums of different volumes. As previously stated, additional drums of various shapes and volumes are provided which can be inserted in place of those shown when desired.

The drums are also immersed in lead baths, and this affords knowledge of skin temperatures and adiabatic control. These baths are also heated electrically, and are arranged in such a manner that temperature gradients through the drum, comparable to commercial practice, may be maintained.

Each cracking zone outlet is provided with a back pressure throttle valve—thereby allowing variable pressure control on each zone.

The evaporator, **7**, may be operated under pressures from atmospheric to 500 pounds. Closed-coil reflux is provided at the top of the tower, below which are baffles. A gage glass is used for liquid level control. The various transfer lines leading to and from the evaporator and the tower itself are adiabatically wound.

The flash tower, **8**, is of similar construction to the evaporator. The bottoms of the towers, **7** and **8**, have removable plates made tight by means of tongue-and-groove companion flanges, using a copper gasket. The bottom flange contains a lead cell, equipped with a thermowell to permit heating the base to a known skin temperature.

The overhead vapors from the evaporator, **7**, and from the flash tower, **8**, pass through towers serv-

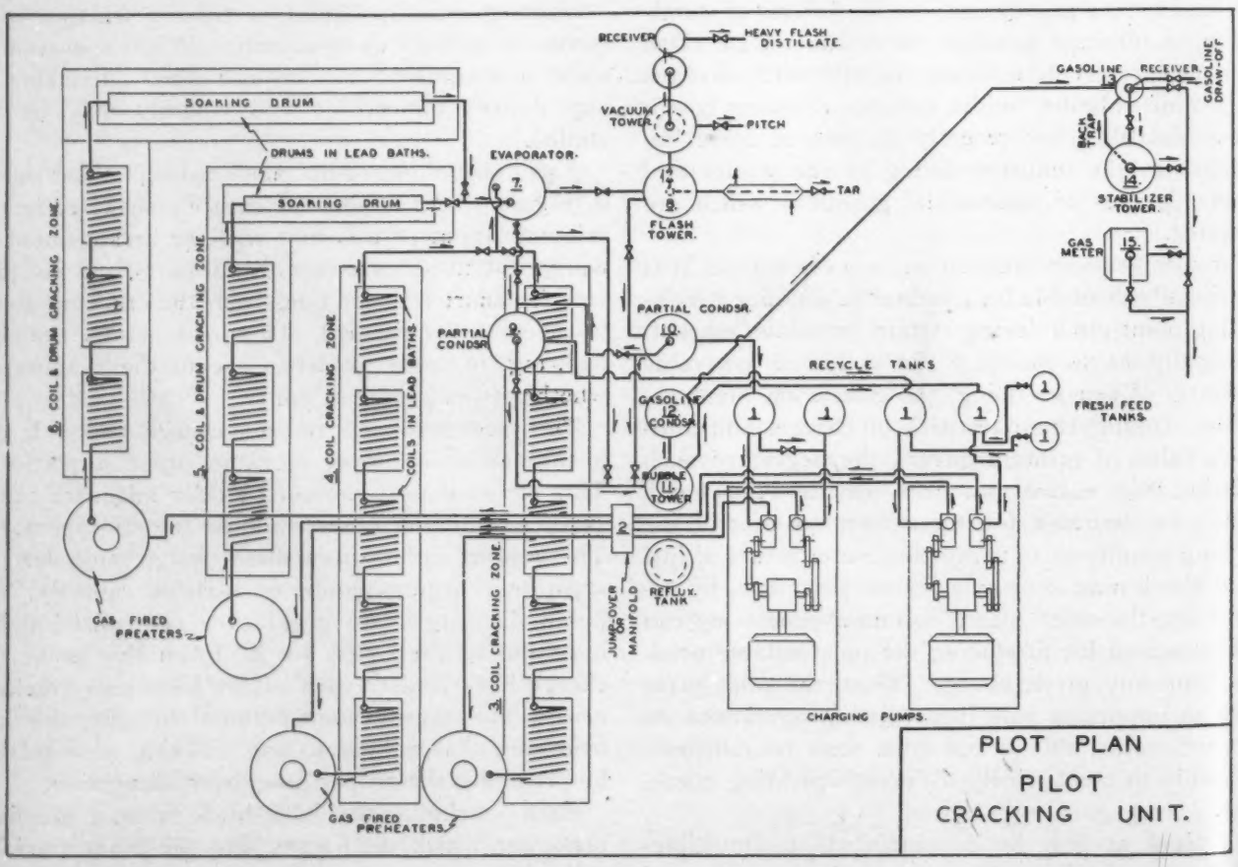


FIGURE 1

ing as partial condensers (**9** and **10**). These towers have closed coil reflux, and are packed with Ascoloy-Lessig rings. These fractionators permit the separation of clean and dirty re-cycle stocks, and in certain cases are also used for fresh-feed fractionating to produce distilled light colored furnace charges. Stocks suitable for severe or mild cracking conditions are thus obtained.

The bubble tower, **11**, is also a packed column with reflux control similar to that of the partial condensers. From the top of the bubble tower, gas and gasoline, the latter of desired end point, pass to the condenser, **12**, and thence to the gasoline receiver, **13**, and stabilizer, **14**. The wet gas passes from the top of the gasoline receiver into the bottom of the stabilizer, which is a refrigerated column. The condensibles from the bottom of the refrigerated column trap back into the gasoline receiver continuously, and are partially reboiled—setting up reflux in the refrigerated column. Dry gas issues from the top of the column and passes to a gas meter, **15**. Control of the refrigerated column and reboiling temperature permits the production of stabilized gasoline of the desired Reid vapor pressure.

The bottoms from the two partial condensers and bubble tower flow to the respective charge tanks; and the pumping rates from these tanks and either the charge rate or cracking conditions are so adjusted as to maintain constant levels.

All operations upon the pilot plants are calculated for a weight balance upon a material input basis, the charges and products being accurately determined. In this manner losses comparable to those in a commercial operation are included. The average run is usually within two per cent to three per cent of the theoretical. Initial "come-up" times of from 12 to 24 hours, wherein recycle and stream gravities are changing, are not included in the yield calculations, which only cover periods when the system is operating at uniform conditions.

To illustrate a "combination" cracking operation and typical information available from such a pilot plant, the following results obtained when processing a Mid-Continent crude are appended.

The crude as received had the following distillation:

A. P. I. gravity	35.6
Distillation, °F.:	
Initial boiling point	192
5 per cent point	250
10 per cent point	280
20 per cent point	348
30 per cent point	411
40 per cent point	482
50 per cent point	562
60 per cent point	629
70 per cent point	662
80 per cent point	690
	cracked

It was pipe-stilled in auxiliary equipment to prepare the various charges for the cracking unit, and yields from this preliminary operation were as follows:

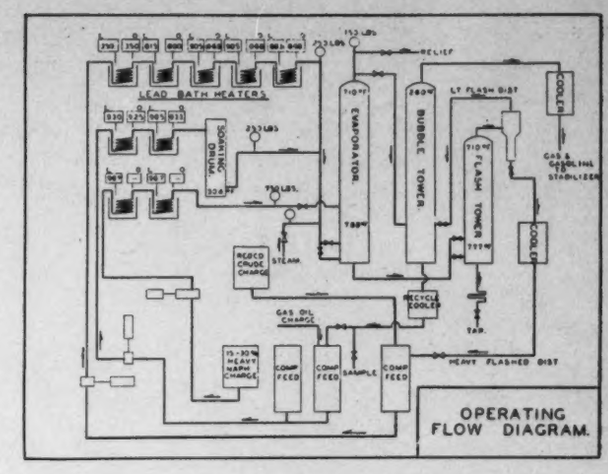


FIGURE 2

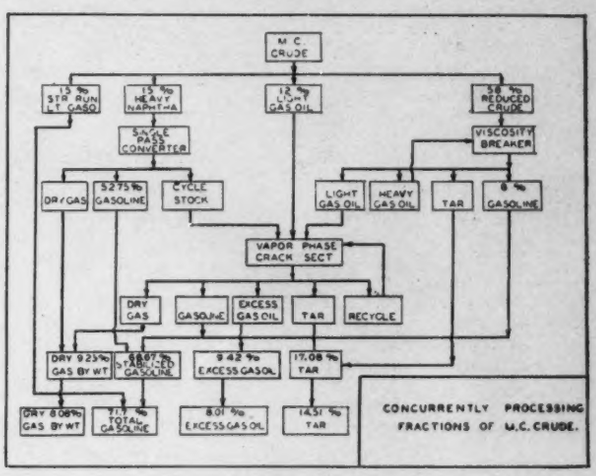


FIGURE 3

	(Per Cent)
Light straight-run gasoline	15.0
Heavy naphtha	15.0
Light gas oil	12.0
Reduced crude	58.0
	100.0

The light straight-run gasoline from the above operation had an octane number of 62, and was reserved for final gasoline blending with the gasoline from the cracking unit; while the heavy naphtha, light gas oil, and reduced crude were charged to the unit in proportion to their yields from the crude. The inspections of these stocks are tabulated in Table 1.

TABLE 1
Inspections of Pilot-Plant Charges

	Light Straight-Run Gasoline	Heavy Naphtha	Light Gas Oil	Reduced Crude
Crude, per cent	0-5	15-30	30-42	42-100
Gravity, A.P.I.	69.2	47.9	40.9	25.5
Distillation, °F.:				
Initial boiling point	112	314	401	490
20 per cent point	165	335	429	604
50 per cent point	199	354	448	686
90 per cent point	250	398	494	Cracked
End point	290	430	537	
Recovery, per cent	97	98	98	
Octane No. (C.F.R.)	62			

The operating flow diagram is shown schematically in Figure 2, and the operating temperatures and pres-

sures in Table 2. A tabulation of the cracks per pass of the various zones, the yields and weight balance, is shown in Table 3.

To visualize more readily the continuity of operations, Figure 3 shows processing from the crude to the products. Table 4 includes inspections of products.

TABLE 2
Operating Conditions

Pressures	(Pounds)
Viscosity breaker	250
Vapor-phase cracking coils	250
Heavy-naphtha converter	750
Evaporator	150
Temperatures (oil outlet)	(Deg. F.)
Viscosity breaker	
Sect. 1 (not heated)	350
Sect. 2	800
Sect. 3	868
Sect. 4	868
Sect. 5	868
Vapor-phase section	
Sect. 1	925
Sect. 2	933
Soaking-drum outlet	904
Temperature (oil outlet)	(Deg. F.)
Heavy-naphtha converter	
Sect. 1	962
Sect. 2	962
Evaporator	
Top	710
Middle	757
Bottom	788
Flash tower	
Top	710
Bottom	770
Bubble tower	
Top	260

TABLE 3
Yields
(Based on Pilot-Plant Charge)

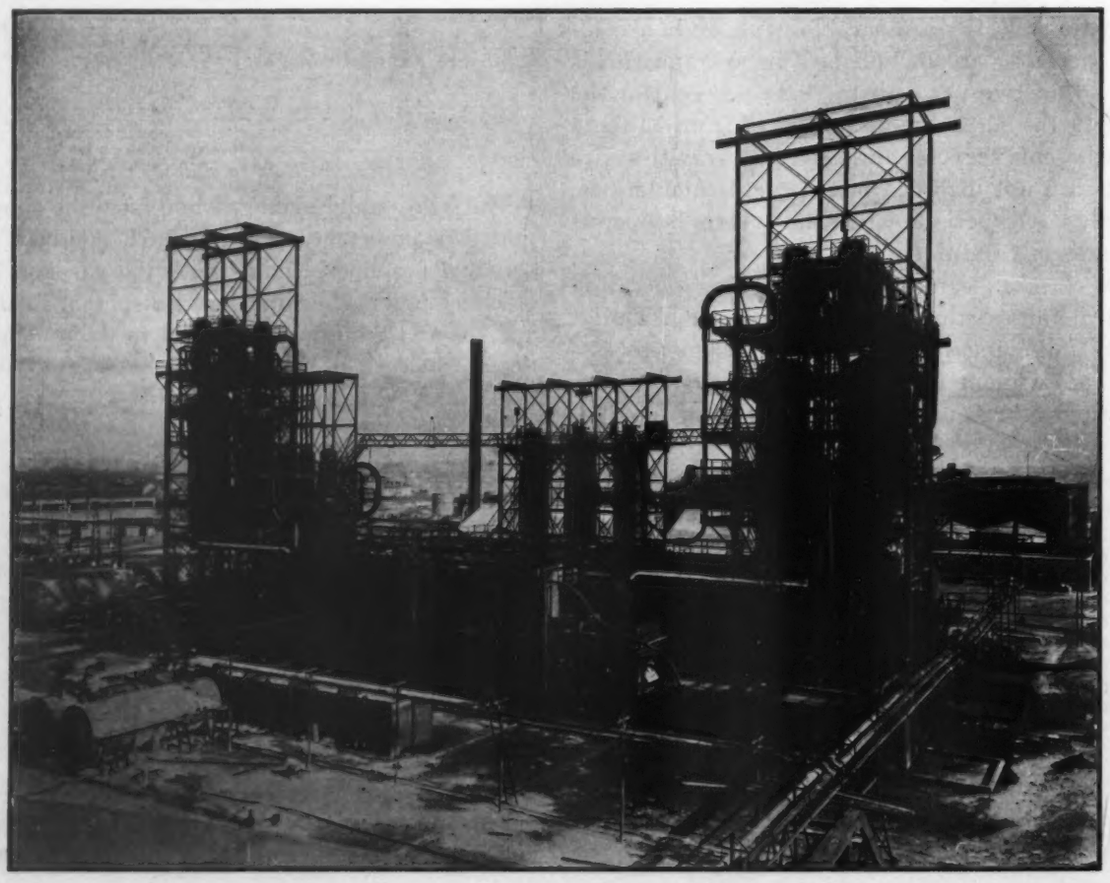
	(Per Cent)
Stabilized cracked gasoline	66.67
Dry gas, by weight	9.25
Tar	17.08
Excess gas oil*	9.42
Weight balance	97.1
Octane Numbers (C.F.R.)	(No.)
Viscosity-breaker gasoline	73.0
Heavy-naphtha converter gasoline	74.5
Vapor-phase cracking-section gasoline	76.5
Stabilized cracked gasoline	75.5
Total stabilized gasoline	74.0
(Based on Crude)	
Total stabilized gasoline	71.70
Dry gas, by weight	8.08
Tar	14.51
Excess gas oil*	8.01

* Part of the excess gas oil would be used for diluting the tar to bunker "C" viscosity, or for sale directly, or would be returned to the unit for cracking.

TABLE 4
Inspections of Products

	Stabilized Cracked Gasoline	Total Stabilized Gasoline*	Bubble-Tower Bottoms†	Tar
Gravity, A.P.I.	59.0	60.6	28.8	3.0
Distillation, deg. F.:				
Initial boiling point	85	88	375	...
20 per cent point	168	163	442	...
50 per cent point	265	240	477	...
90 per cent point	358	350	604	...
End point	378	376	666	...
Recovery, per cent	97.5	98	97.5	...
Octane No. (C.F.R.)	75.5	74	...	...

* Blend of cracked and light straight-run gasoline.
† Re-cycle to vapor-phase furnace.



Cracking Light and Heavy Oils

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THE demand for octane numbers is still growing, with the result that the cracking of light and heavy oils is increasing to meet the demand for anti-knock motor fuel.

Progress in the art of cracking during the past few years has been especially marked by the conversion of straight-run gasolines and naphthas into high-octane gasolines, due to their original unsuitability as motor fuel in modern cars. The cracking of heavy oils into high-octane gasoline has also kept pace with the needs of the time.

It is interesting to compare the percentage yields of straight-run gasoline versus the cracked product from crude oil produced during the years 1918 to 1933 in the United States, which indicates that the day may come when practically all gasoline will be processed to improve its anti-knock properties.

TABLE 1
Percentage Yields Straight-Run Versus Cracked Gasoline

Year	Total Gasoline (Per Cent Yield from Crude Oil)	Cracked Gasoline (Per Cent of Total Gasoline)	Straight-Run Gasoline (Per Cent of Total Gasoline)
1918	26.1	10.0	90.0
1919	26.1	10.5	89.5
1920	26.8	12.9	87.1
1921	27.7	16.3	83.7
1922	29.5	20.8	79.2
1923	30.9	19.4	80.6
1924	33.1	18.8	81.2
1925	35.0	26.4	73.6
1926	31.2	31.2	68.8
1927	30.6	30.6	69.4
1928	32.5	32.5	67.5
1929	33.0	33.0	67.0
1930	38.0	38.0	62.0
1931	40.3	40.3	59.7
1932	42.8	42.8	57.2
1933 (January-February)	44.5	53.3	46.7

The cracking results on various stocks are reported under the following divisions:

1. Straight-run gasoline and naphtha
2. Gas oil
3. Fuel oil
4. Light and heavy oil

CRACKING STRAIGHT-RUN GASOLINE AND NAPHTHA

Competitive conditions are forcing the industry to increase the octane number of gasolines, which necessitates the cracking of straight-run gasoline and naphtha relatively low in octane values.

Economically, the processing of these stocks appears, under certain conditions, to be unwarranted; for one starts with a gasoline having satisfactory properties in all respects except octane rating and incurs the expense of a cracking operation, plus loss of gasoline. Yet, without cracking, many of the gasolines distilled from crude oil are unsalable or are sold as third-grade products. With a number of crude oils it is more economic to distill out a low-boiling fraction and crack the naphtha instead of reforming the entire gasoline. In certain cases it is necessary to process the gasoline in its entirety, due to the fact that all fractions thereof are of low octane rating.

It is interesting to point out that, in processing high-sulfur gasolines, reforming (or cracking) reduces the sulfur content of the gasoline substantially. In reforming a West Texas gasoline containing 0.19 per cent sulfur, the product of 76 octane number had a sulfur content of 0.07 per cent.

A number of refiners who are reforming gasolines do not refine the product beyond the addition of an inhibitor to keep the gum down, with or without the use of a dye to color the finished gasoline.

Although the processing of straight-run gasoline and naphtha on a "once-through" cracking basis under temperatures to 1000°F. and pressures to 750 pounds on the heating coil have been satisfactory in producing high-octane gasoline, it is thought that in view of the limited flexibility of a unit without a reaction chamber provision should be made in the design for a reaction chamber, so that, if found necessary, at a later date, hot-oil pumps and auxiliary equipment for the re-cycle operation may be installed to process any type of charging stock.

Cracking tests were conducted on Pennsylvania, Mid-Continent, and mixtures of Mid-Continent and West Texas gasolines and naphthas, and also Joiner (Texas), and East and West Texas gasolines, the results of which are shown in Tables 2 and 3.

The results of cracking Mid-Continent and West Texas gasolines and naphthas therefrom are reported in Table 3, which include the blending of the light gasoline fraction, distilled from the whole with the product from naphtha reforming. On the basis of these experiments, there seems to be no particular advantage, as far as yield and octane number of the

TABLE 2

Gasoline and Naphtha Cracking Stocks

Source	Pennsylvania	Pennsylvania	Joiner and East Texas	Joiner and East Texas	East and West Texas
Type	Straight-Run Gasoline	Straight-Run Naphtha	Straight-Run Gasoline	Straight-Run Gasoline	Straight-Run Gasoline
ANALYSIS OF CHARGING STOCKS					
Gravity, deg. A.P.I.	64.6	54.9	58.7	58.7	61.3
A.S.T.M. distillation, in deg. F.:					
Initial boiling point	106	180	124	124	93
10 per cent point	154	248	174	174	146
20 per cent point	186	264	196	196	180
50 per cent point	242	299	255	255	248
90 per cent point	328	366	356	356	348
End point	386	414	410	410	401
Sulfur, per cent	...	...	0.02	0.02	0.16
Octane No. (C.F.R. research)	50	31	56	56	59
ANALYSIS OF CRACKED GASOLINE					
Gravity, deg. A.P.I.	63.6	58.1	58.8	60.6	61.0
A.S.T.M. distillation, in deg. F.:					
Initial boiling point	94	100	116	93	91
10 per cent point	121	165	157	158	139
20 per cent point	144	202	185	183	165
50 per cent point	216	263	247	241	235
90 per cent point	327	345	347	346	337
End point	378	375	379	375	389
Sulfur, per cent	0.01	0.02	0.02	0.02	0.09
Octane No. (C.F.R. research)	75	76	75	71	73
OPERATING CONDITIONS					
Pressure, lb. per sq. in.	400	500	500	500	450
Temperature, deg. F.	1,000	950	950	950	995
YIELDS PER CENT BY VOLUME OF CHARGE					
Cracked gasoline	76.7	73.5	84.4	88.1	85.8
Residuum	1.4	10.1	1.0	2.7	0.0
Gas and loss	21.9	16.4	14.6	9.2	15.6
Gas, cu. ft. per bbl. of charge	704	560	403	244	400

TABLE 3

Gasoline and Naphtha Cracking Stocks

Source	Mid Continent	Mid Continent	West Texas	West Texas
Type	Gasoline	Naphtha (300-Deg.-F. End-Point Cut Removed)	Gasoline	Naphtha (260-Deg.-F. End-Point Cut Removed)
ANALYSIS OF CHARGING STOCKS				
Gravity, deg. A.P.I.	59.8	53.5	58.1	51.5
A.S.T.M. distillation, in deg. F.:				
Initial boiling point	115	222	95	220
10 per cent point	177	263	160	261
20 per cent point	213	277	200	280
50 per cent point	277	309	274	312
90 per cent point	347	353	364	370
End point	383	385	392	410
Sulfur, per cent	0.02	0.02	0.18	0.19
Octane No.	42	34	61	52

ANALYSIS OF CRACKED GASOLINE

			Gasoline (Blending of Light Cut with Reformed Naphtha at Left)			Gasoline (Blending of Light Cut with Reformed Naphtha at Left)
Gravity, deg. A.P.I.	60.9	55.5	60.5	59.6	54.8	57.7
A.S.T.M. distillation, in deg. F.:						
Initial boiling point	104	91	90	99	96	108
10 per cent point	154	164	138	147	172	150
20 per cent point	186	204	167	180	218	179
50 per cent point	255	280	236	257	282	248
90 per cent point	346	358	334	370	362	370
End point	376	382	366	400	396	392
Sulfur, per cent	0.01	0.02	...	0.05	0.07	0.08
Octane No.	70	75	69	78	78	77
OPERATING CONDITIONS						
Pressure, lb. per sq. in.	500	500	...	750	750	...
Temperature, deg. F.	975	1,000	...	950	950	...
	Yields, Per Cent by Volume of Charge		Per Cent by Volume of Entire Gasoline	Yields, Per Cent by Volume of Charge		Per Cent by Volume of Entire Gasoline
Cracked gasoline	82.3	75.5	81.6	87.4	80.4	86.2
Residuum	1.2	2.5	...	2.0	5.9	...
Gas and loss	16.5	22.0	...	10.6	13.7	...
Gas, cu. ft. per bbl. of charge	395	781	...	342	451	...

TABLE 4
Gas-Oil Cracking

Source	Pennsylvania	Mid Continent	East Texas	Coastal	California	California
ANALYSIS OF CHARGING STOCKS						
Gravity, deg. A.P.I.	38.8	35.3	32.0	28.5	34.5	26.1
A.S.T.M. distillation, in deg. F.:						
Initial boiling point	380	448	482	428	460	496
10 per cent point	494	488	522	468	484	551
20 per cent point	554	504	540	486	495	592
50 per cent point	628	546	610	532	525	675
90 per cent point	718	664	...	640	620	753
End point	760	731	...	688	690	760+
Percentage at 437	4.5	0.0	0.0	1.5	0.0	0.0
Percentage at 572	26.0	64.0	38.0	68.0	77.5	15.0
Sulfur, per cent	0.05	0.32	0.23	0.1	0.59	0.99
OPERATING CONDITIONS						
Pressures, lb. per sq. in.	350	350	350	400	350	350
Temperature, deg. F.	950	965	950	950	950	950
YIELDS, PER CENT BY VOLUME OF CHARGE						
Cracked gasoline	70.5	65.2	61.8	63.8	70.8	61.3
Residuum	11.0	15.1	22.0	18.3	15.9	29.0
Gas and loss	18.5	19.7	16.2	17.9	13.3	9.7
Gas, cu. ft, per bbl. of charge	460	698	640	796	487	520
ANALYSIS OF PRODUCTS						
CRACKED GASOLINE						
Gravity, deg. A.P.I.	62.2	61.0	60.5	52.8	57.9	55.6
Sulfur, per cent	0.02	...	0.10	0.05	0.24	...
A.S.T.M. distillation, in deg. F.:						
Initial boiling point	88	84	86	97	88	92
20 per cent point	175	166	169	181	175	186
50 per cent point	259	252	252	272	274	283
90 per cent point	357	360	376	377	385	408
End point	376	392	396	401	401	429
Octane No. (C.F.R. research)	76	80	75	90	77	79
CRACKED RESIDUUM						
Gravity, deg. A.P.I.	7.3	7.0	3.6	—1.5	0.1	4.4
Basic sediment and water, per cent	0.3	0.3	0.4	0.6	0.6	0.4
Viscosity, Saybolt Universal, at 122 deg. F.	54	18	47	218	80	92
Flash point (Cleveland open cup)	235	200	225	215	223	275
Fire point (Cleveland open cup)	295	255	285	250	260	330
Flash point (Pensky-Martens)	150	...	160	205	165	200
Cold test, deg. F.	—0	—0	25	50	15	35
A.S.T.M. distillation, in deg. F.:						
Initial boiling point	436	376	468	450	444	495
Percentage at 572	9.0	31.1	14.5	20.5	29.0	5.0

gasolines are concerned, whether the straight-run gasolines or the naphthas are cracked separately or not.

When producing gasoline by blending the reformed naphtha product with the light ends of the straight-run gasoline from which the naphtha was derived, the octane number of the final gasoline is a function of the amount of naphtha reformed.

As the per cent of naphtha which must be reformed to obtain a given octane number increases, a point is reached where it is more economic to process the entire gasoline, rather than go to the expense of fractionating out a small percentage of light fractions.

CRACKING GAS OILS

Some refiners produce gas oil as a by-product of their refinery operation, whereas others produce it to provide charging stock for their cracking units. Gas oils are excellent stocks for conversion into motor fuel of high octane value.

A series of cracking runs made on gas oils, derived from Pennsylvania, Mid-Continent, East Texas, Coastal, and California crude oils yielded gasolines having octane numbers ranging from 74 to 90, with yields from 61 per cent to 71 per cent of the charging stocks.

In general, it has been observed that under similar conditions the source of charging stock has a direct bearing upon the octane number of the cracked gasoline. However, gasolines of equal octane number can be produced from any stock under proper operating conditions.

The cracking results relating to the various gas oil stocks are shown in Table 4.

FUEL-OIL CRACKING

Fuel oils from various crudes have been processed not only to produce high-octane gasoline, but also residues which meet or better bunker "C" specifications.

As far as coke formation is concerned, fuel-oil charging stocks are often considered more difficult to process than gasoline, naphtha or gas oil. However, a combination of correct principles, good de-

TABLE 5
Fuel-Oil Cracking

Source	Mid Continent	Kentucky	Montana (Kevin Sunburst)	New Mexico Hobbs	California (Santa Fe Springs)	California
ANALYSIS OF CHARGING STOCKS						
Gravity, deg. A.P.I.	25.3	23.4	27.3	27.8	19.8	17.8
A.S.T.M. distillation, in deg. F.:						
Initial boiling point	553	474	510	230	462	420
10 per cent point	...	544	556	343	592	561
20 per cent point	...	588	571	400	644	623
50 per cent point	700	688	610	608	697	689
90 per cent point	...	734	718	...	...	...
End point	...	744	...	...	...	...
Percentage at 437	...	0.0	0.0	25.5	0.0	Trace
Percentage at 572	...	17.0	21.5	44.5	8.0	12.0
OPERATING CONDITIONS						
Pressure, lb. per sq. in.	250	265	300	350	250	250
Temperature, deg. F.	915	900	950	935	929	890
YIELDS, PER CENT BY VOLUME OF CHARGE						
Cracked gasoline	51.2	55.1	60.2	63.3	40.7	38.9
Residuum	41.8	40.9	29.1	29.2	53.2	58.1
Gas and loss	7.0	4.0	10.7	7.5	6.1	3.0
Gas, cu. ft. per bbl. of charge	309	298	505	391	312	290
ANALYSIS OF PRODUCTS						
CRACKED GASOLINE						
Gravity, deg. A.P.I.	61.0	58.3	57.1	56.0	58.1	59.0
A.S.T.M. distillation, in deg. F.:						
Initial boiling point	82	86	96	99	102	94
10 per cent point	135	147	138	160	132	141
20 per cent point	172	187	175	201	186	185
50 per cent point	266	285	275	284	276	268
90 per cent point	372	378	390	370	388	353
End point	396	392	402	401	408	372
Octane No.	72.0	76	81	76	75	79
RESIDUUM						
Gravity, deg. A.P.I.	9.5	9.1	3.6	3.7	8.3	8.9
Basic sediment and water, per cent	0.9	0.5	0.2	0.4	0.9	0.9
Viscosity, Saybolt Universal, at 122 deg. F.	180	103	38	243	166	168
Flash point (Cleveland open cup)	...	260	245	205	280	245
Fire point (Cleveland open cup)	...	345	295	320	360	325
Flash point (Pensky-Martens)	...	220	175	195	225	205
Cold test, deg. F.	0	28	—0	50	45	35
A.S.T.M. distillation, in deg. F.:						
Initial boiling point, deg. F.	...	458	454	437	452	430
Percentage at 572	...	9.0	16.5	11.0	4.0	12.0

sign, and proper operation makes possible long runs producing high-octane gasoline from heavy oils.

In addition, by cracking fuel oil, either topped or reduced crude, in its entirety, the cost of distilling out the gas-oil fraction is eliminated. As an illustration, a unit processing over 4200 barrels a day of 25.3 gravity Mid-Continent fuel oil produced during 27.5 continuous days (total 115,941 barrels of charge) 51.2 per cent of Gray vapor-phase-treated gasoline having a 72 octane number direct from the cracking unit. The details are given in Table 5, first column. This same unit has been producing cracked gasoline for the past 41 days, and at this writing is still on stream.

Table 6 shows the results of cracking Smackover topped crude producing high anti-knock gasoline better than bunker "C" fuel oil and heavier residues, as well as results from non-residue operation. Although the yield of gasoline ranged from 39 per cent to 63 per cent by volume, the anti-knock value of the gasoline produced remained constant at 80 octane number. Simultaneously, the gas formation increased from 251 to 970 cubic feet per barrel of charge.

LIGHT- AND HEAVY-OIL CRACKING

A highly flexible cracking process converts the naphtha fraction in one heating coil and the fuel-oil residue in another, after first topping out a light gasoline fraction of high anti-knock value.

A unit of this design is used to produce very high-octane gasoline, and combines the reforming of gasoline or naphtha with the regular cracking operation. This type of installation has definite advantages when an over-all high-octane gasoline is desired in the refinery, and is complete for gasoline production. It is a topping, reforming, viscosity-breaking, and cracking unit all in one.

When a refinery is so situated that its chief demand is for high-octane gasoline, this is a highly economic unit to operate.

It is interesting to note from Table 7 that a yield of 68.5 per cent of 75 octane gasoline is obtainable from East Central Texas crude oil, and that the cracked fuel-oil residue passes bunker "C" specifications.

In addition to this, cast Texas crude-oil cracking run, many tests have been made with other oils which show that by two-coil cracking any octane gasoline desired can be obtained with minimum gas formation.

TABLE 6
Cracking Smackover Topped Crude

ANALYSIS OF CHARGING STOCKS					
Gravity, deg. A.P.I.	17.9	17.9	17.9	17.9	17.9
Sulfur, per cent	2.2	2.2	2.2	2.2	2.2
A.S.T.M. distillation, in deg. F.:					
Initial boiling point	426	426	426	426	426
10 per cent point	531	531	531	531	531
20 per cent point	591	591	591	591	591
50 per cent point	713	713	713	713	713
90 per cent point	...	...	...	...	...
End point	...	...	...	...	...
Percentage at 437	0.5	0.5	0.5	0.5	0.5
Percentage at 572	17.0	17.0	17.0	17.0	17.0
OPERATING CONDITIONS					
Pressure, lb. per sq. in.	200	200	200	200	200
Temperature, deg. F.	935	935	935	935	935
YIELDS, PER CENT BY VOLUME OF CHARGE					
Cracked gasoline	39.0	45.2	48.8	50.2	63.1
Residuum	58.4	48.0	46.0	44.8	None
Gas and loss (coke)	2.6	6.8	5.2	5.0	36.9
Gas, cu. ft. per bbl. of charge	251	408	458	446	970
Coke, lb. per bbl. of charge	...	...	...	...	93
ANALYSIS OF PRODUCTS					
CRACKED GASOLINE					
Gravity, deg. A.P.I.	57.1	57.0	55.3	55.6	55.1
Sulfur, per cent	0.24	0.24	0.22	0.25	0.26
A.S.T.M. distillation, in deg. F.:					
Initial boiling point	94	96	95	91	85
10 per cent point	148	150	153	148	147
20 per cent point	187	186	190	188	188
50 per cent point	276	276	285	268	281
90 per cent point	378	374	382	389	380
End point	397	392	406	409	399
Octane No.	80	80	80	80	80
CRACKED RESIDUUM					
Gravity, deg. A.P.I.	8.7	4.8	2.6	0.7	
Basic sediment and water, per cent	0.4	0.3	0.4	0.5	
Viscosity, Saybolt Universal, at 122 deg. F.	159	357	637	1,411	
Flash point (Cleveland open cup)	...	...	255	255	Coke
Fire point (Cleveland open cup)	...	...	330	335	pro-
Flash point (Pensky-Martens)	...	...	220	210	duced
Cold test, deg. F.	...	...	50	70	
A.S.T.M. distillation, in deg. F.:					
Initial boiling point	...	...	470	483	
Percentage at 572	...	...	9.0	6.0	

TABLE 7
East Texas Crude Cracking

BREAK-UP OF CRUDE BEFORE CRACKING	**Per Cent of Crude**
Light gasoline (300 deg. F. end point, octane No. 71)	15
Naphtha	25
Topped crude	60

CRACKING YIELDS BASED ON TOPPED CRUDE AND NAPHTHA	**Run "A"**	**Run "B"**	**Estimated Yields When Producing 300-Viscosity Residue**
Gasoline, per cent of topped crude and naphtha	55.0	57.5	63.0
vapor pressure, Reid, lb. per sq. in.	11.0	11.0	11.0
end point, deg. F.	410	390	400
octane No.	77	74	77
Residuum, per cent of topped crude and naphtha	33.7	34.9	22.0
gravity, deg. A.P.I.	14.9	12.6	8.0
basic sediment and water, per cent	0.3	0.2	0.3
viscosity, Saybolt Universal, at 122 deg. F.	45	86	300
Loss, per cent of topped crude and naphtha	11.3	7.6	15.0
YIELDS BASED ON ENTIRE CRUDE			
Cracked gasoline, per cent	46.8	48.8	53.5
Straight-run gasoline, per cent	15.0	15.0	15.0
Total gasoline, per cent	61.8	63.8	68.5
octane No.	75	73	75
Residuum, per cent	28.6	29.6	18.8
Loss, per cent	9.6	6.6	12.7

Solvent Dewaxing of Oils With Benzol and Acetone

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THE solvent process of dewaxing lubricating oils, using a solvent consisting of a mixture of benzol and acetone, has been in successful commercial use at the Lawrenceville, Illinois, refinery of the Indian Refining Company since 1927.

The process consists fundamentally of the following steps:

a. Oil from which wax is to be removed is diluted in the proportion of 3 or 4 to 1 with a solvent composed of a mixture of approximately 35 per cent acetone and 65 per cent benzol.

b. Wax is precipitated from the solution by chilling to a temperature of approximately the pour test desired in the dewaxed oil.

c. The chilled mixture is forced through a filter to separate the precipitated wax from the oil solution.

d. The solvent is separated from the filtrate by distillation, yielding a dewaxed oil having a pour test substantially equal to the temperature at which the filtration of wax from the solution occurred.

e. The solvent is recovered from the wax filtercake by distillation, the recovered solvent from the filter-cake and from the filtrate being re-cycled in the process for the dewaxing of further oil.

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THE apparatus used at the company's Lawrenceville plant is as follows:

1. Mixing tanks for mixing solvents and oil.
2. Refrigeration and chilling equipment for cooling oil.
3. Filters.
4. Solvent-recovery stills.
5. Flue-gas system.
6. Pumps and drives.
7. Process tanks.

There are three 500-barrel mixing tanks manifold to a centrifugal mixing pump with the necessary filling and emptying lines. These mixing tanks are gas-tight, built for 75-pound operating pressure, and are manifolded to a common gas header on top with no venting to the atmosphere. The tanks are designed to stand the pressure exerted by filling all tanks two-thirds full with solvent at 125°F.—although in actual operation the pressure on these tanks has never exceeded 15 pounds per square inch.

The exchangers and chilling equipment consist of three independent sets of double-pipe chillers, each set having 32 exchanger pipes, 24 pipes in the first-stage chiller, and 20 pipes in the second-stage chiller. The exchangers and chillers are of conventional type with six-inch inside pipes equipped with screw conveyors and eight-inch jacket pipes. Pumps take suction on the mixing tanks, pumping wax distillate mix—first through the exchangers, counter-current to filtrate flow; then through the chillers, counter-current to brine flow.

The chilled wax distillate flows to a 500-barrel brine-jacketed surge tank. The pressure on this tank is maintained at 40 pounds per square inch by gas from the flue-gas system. From the surge tank the chilled-wax distillate mix flows to the filters under the pressure maintained in the surge tank. The flow through the plant can be traced in Figure 1.

The filtering equipment used is of the rotating-leaf pressure type. Each of the filters consists of a filter element made up of 21 leaves, 48-inch in diameter, mounted on a six-inch hollow shaft. Each leaf consists of two circular, perforated plates spaced about one fourth-inch apart. The space between the perforated plates is divided into four quarters, and the plates are fabricated into a unit around a central hub and an outer ring. Filter cloths are attached to both sides of the leaves, by means of clamping rings.

The leaves are assembled on a hollow shaft in such a manner that ports through the hub in the leaf are over ports in the hollow shaft. Gaskets are used to make pressure-tight joints between the hubs. The filter shell is a cylindrical vessel, divided on the horizontal center line into two halves. The end spindles which support the filtering element are journaled in large bearings and stuffing boxes.

The entire element is mounted in a shell—by means of flanged couplings—to a rotating drive shaft at one end and to a hollow filtrate-discharge spindle at the other end. The bottom of the shell is trough-shaped, and contains a right- and left-hand screw conveyor. There are four four-inch openings in the lower part of the shell for slurry inlet, and a 12-inch opening in the bottom of the shell for cake discharge. A single

worm-and-bevel gear drive is mounted on one end to drive the rotating filtering element, and operate the screw conveyor.

There are 12 rotating-leaf filters installed in an insulated room in which the temperature is maintained from 10° F. to 30° F. The drives and all controls for the operation are outside of the press room. The connections on the filter consist of a wax-distillate-mix inlet, filtrate outlet, flue-gas inlet, blow-back outlet, slack-wax-mix outlet, and wash inlet.

The press room is equipped with an overhead travelling chain hoist in order to remove filtering elements from the equipment for repairs. The filtering medium is 2/0 cotton duck blanket, similar to that used on plate and frame filter presses. Occasionally, when leaky blankets develop, it is necessary to remove the filtering element and replace with a spare which is kept on hand. The overhead hoist enables the operators to remove the upper half of the shell of the filter and to disconnect and remove the filtering element. The spare element is dropped into place and the filter closed up—the entire operation requiring about four men for five hours to accomplish it. The average life of the blankets is more than seven months, and in rare instances it is necessary to remove filtering elements in less than seven months.

The strippers consist of two stills in series, heat exchangers, condensers, receivers, exhaust-steam preheater, and fired heater. There are two units for stripping: one for stripping the solvent from the pressed distillate, the other for stripping the solvent from the slack wax. The flow is identical in each, and is illustrated in Figure 1.

The flu-gas system consists of a scrubber, compressor, water and brine coolers, and gasometer. Flue gas is taken from the breeching at the boiler house by steam jet, and is blown through a three-bubble deck-water scrubbing column to the gas holder. The compressor takes suction on the gas holder, and compresses the gas to 40 pounds per square inch. The compressor used is a two-stage, standard, synchronous motor-driven air compressor with five-step clearance-pocket control. Using two-stage compression, the maximum temperature of the gas through the compressor never exceeds 160° F. A water cooler (inner and after cooler) cools the gas to water temperature, and just prior to admission to the filters the gas is further cooled by cold brine to 0° F. An amount varying between 400 and 700 cubic feet of gas per minute is required in normal operation—all of which comes from circulation within the plant. All that is required for make-up is 30 cubic feet per minute.

METHOD OF OPERATION

The acetone-benzol mixture which is used as the solvent is stored in gas-tight storage tanks. This mixture consists of 35 per cent acetone and 65 per cent industrial, non-corrosive, 90 per cent benzol. Deepening upon the character of the stock being dewaxed, the required proportion of solvents is pumped to a gas-tight mixing tank—liquid levels being shown by indicating gages. After the required solvent has been put into the mixing tank, the necessary amount of wax distillate is pumped in on top of the solvent and the entire body of liquids mixed by means of a circulating pump—the temperature of the mixture varying from 70° F. to 90° F. No heat is added in mixing the solvent and wax distillate, as the recovered solvent and wax distillate are at a sufficient temperature as a result of ordinary processing to make the addition of heat unnecessary. There are three mixing tanks, and all mixing is done in batch.

Suction is taken on the mixing tank, and the mixture of solvent and wax distillate is pumped through continuous chilling equipment—the first part of

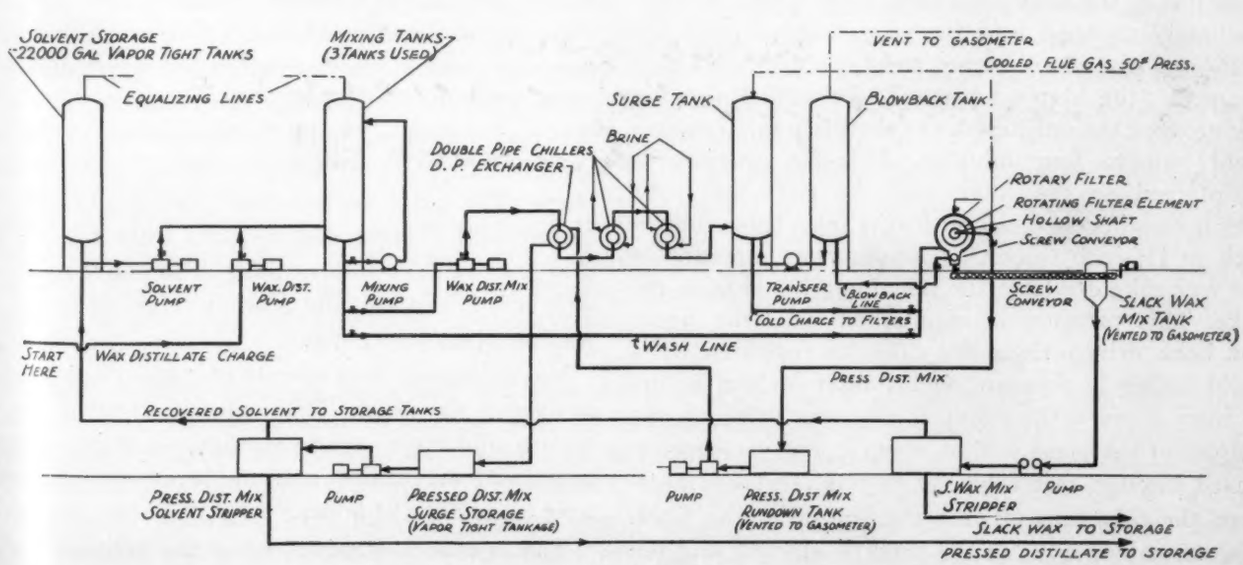

FIGURE 1

Flow Diagram—Solvent Dewaxing Process, Indian Refining Company, Lawrenceville Works.

which consists of exchangers—exchanging heat with the cold-pressed distillate mix from the press. In this exchange the wax-distillate mix is cooled from its mixing temperature down to a temperature of 25° F. After having passed through the exchangers, the wax-distillate mix goes through brine-cooled chillers and then into the surge tank.

The process is unique in its ability to produce dewaxed oil having a pour test not substantially higher than the temperature at which filtration of the wax from the wax-distillate mix takes place. As a result of this unusual feature the process can produce economically, and on a commercial scale, dewaxed lubricating oils having a pour test many degrees lower than the lowest pour test attained in the dewaxed lubricating oils now on the market. For example, the process is capable of producing oils having a pour test as low as — 40° F.

In the operation of the plant which is under discussion a dewaxed oil of 0° F. to — 5° F. was required, and the wax-distillate mix leaves the chillers at a temperature of 3° F. to 5° F. below this temperature.

From the surge tank the wax-distillate mixture is fed by the pressure (40 pounds per square inch maximum) maintained on the surge tank of the filters.

In the cycle of operations wax-distillate mix is admitted to the filters through the four four-inch openings—filling the shell of the filter, and submerging the element. The liquid flows through the cloth on each leaf into the space between two plates on each leaf, out through the hub and into the hollow shaft. The slack-wax mix is retained on the leaf. The feed to the filter is open for 25 minutes. The wax-distillate-mix inlet is then closed, and the blow-back valve opened. Flue-gas pressure is opened into the top of the filter—displacing all of the unfiltered wax-distillate mix from the filter back through the blow-back line to the blow-back tank, from which it is immediately pumped into the surge tank. When the unfiltered wax-distillate mix has been displaced from the press, the blow-back valve is closed. Emptying the press of the unfiltered wax-distillate mix requires from two to four minutes. Flue-gas pressure is maintained on the filter, and the slack-wax cake which remains on the filter leaf is from three fourth-inch to 1½-inch thick. Maintaining gas pressure on the wax cake displaces the remaining liquid from the cake. This pressure is maintained until the liquid has been driven from the cake, as indicated by a rapid falling in pressure on the filter—which occurs in from seven to 10 minutes. The wax valve on the bottom of the press is then opened, and pressure released through this valve. With this release in pressure, the cake falls off into the bottom of the filter. The screw conveyor in the press is started, and the wax discharged through the wax valve into another lateral screw conveyor that is common to all filters, and the wax conveyed to a slack-wax sump. The passage of the slack-wax cake through the two conveyors reduces the cake to a magma, and it is pumped from the sump with a rotary pump to the solvent stills. The filtrate from the filters flows into a run-down tank by gravity, from which it is pumped through the exchangers to the solvent strippers.

The filters are operated on a definite time cycle of 25 minutes for filtering, 10 minutes for blowing, and 10 minutes for dumping. One man operates up to six filters on a prescribed schedule. The time interval between filters is controlled by the number of filters on the line, and is regulated to keep a constant rate of flow on charge and filtrate. Two clocks in each end of the filter-control room enable the operators to keep the filters on schedule.

Both the pressed distillate and slack-wax mix contain portions of the solvents, and from this intermediate storage they are pumped to the strippers where the acetone-benzol is distilled off—leaving a pressed distillate in one instance and a 110-115-melting-point slack wax in the other.

The charge passes through the vapor-heat exchanger, exhaust-steam heater, and to the first still. Of the solvent 80 per cent is flashed off when entering the still—from the heat picked up in the exchangers and steam heater. A turbine-driven centrifugal pump takes suction on the still, and circulates the oil through the fired heater and back to the still. The fired-heater outlet is maintained at 425° F. An amount equivalent to the oil content of the charge is constantly bled from the heater circulation to the second still, where open-steam strips the last traces of solvent. The condensate and solvent from the second still are separated in the receiver by settling and decantation. The exhaust steam from the turbine-driven circulating pump is used in the steam heaters for pre-heating the charge. Liquid seals are maintained on the receiver outlets, which are filled with the oil being processed. There are no non-condensable gases in the distillation; consequently, there is no breathing out through the receivers. The oil in the seal forms a liquid back-pressure valve, and prevents any loss of solvent vapors to the atmosphere. The seals are emptied periodically into the solvent-still charge, and re-filled from the oil discharged from the solvent stills. The entire operation is synchronized and the solvent returned to the dewaxing plant for re-use.

Not to exceed 2000 barrels of solvent are required to operate the plant. This includes all solvent in the system and intermediate storage, so that in normal operation the entire solvent inventory is turned over twice each 24 hours.

The operation depends upon the stocks handled. As will be shown later, the plant is flexible, so that a wide range of charge stocks can be dewaxed by

this method. The factors influencing the method of operation are the viscosity of the wax distillate and the specifications required of the pressed distillate. The viscosity of the wax distillate influences the proportion of solvents required in the original wax-distillate mixture. The specifications required of the pressed distillate control the temperature of dewaxing. The pour test is practically identical with the dewaxing temperature. However, in order to provide a safe operating margin, the temperature on leaving the chillers is usually maintained at about 5° F. below the pour test required.

A small laboratory is maintained in connection with the solvent dewaxing plant, and it is the duty of this laboratory to prescribe the proper mixing and processing necessary for a given stock. After physical testing of the wax distillate, a mix order is given to the pumper—specifying the amounts of solvents and wax distillate to be blended in the mix, and setting forth the operating temperature at which the mixture is to be chilled. At periodic intervals samples are drawn from the wax distillate entering the chillers, and tested by distillation—as a check on the accuracy of the mixture. The condensate from this laboratory distillation is tested with a hydrometer, in order to keep a check upon the proportion of acetone-benzol within the mixture.

Samples are also taken from the pressed distillate, and analyzed by the same method; and pour tests are run on the pressed distillate after stripping of solvent, in order to forestall any trouble due to leaks in filtering equipment, and in order to insure maintaining products on test. Any leaks developing in the filtering equipment, however, are immediately apparent in the pressed distillate by visual inspection; and it is a simple matter for the operators to isolate the equipment and take the necessary steps to remedy the trouble.

For stock-inventory purposes the laboratory is also required once each month to sample all tanks which have solvents in them, and to analyze the percentage of the mixture. From these analyses and inventory gages it is possible to determine accurately the solvent losses. In the early period of development this procedure was necessary daily; however, solvent losses have now been reduced to a point where it is impossible to detect such losses from day to day, and only at periodic intervals is a check-up made—other than the total liquid content of the system, which is computed daily.

During normal operation 10 presses are kept on the line—with one press washing and one held as a spare. Each press is washed once each shift, and in this manner filtering rates are kept at a maximum. Once during each shift each press is dropped from the operating cycle and washed. This consists of filling the filter one-half full of warm mix and rotating the element in the warm solution. This washes the blankets clean, and results in higher rates of filtration.

Low rates in filtering are caused by improper mixing, by incorrect proportioning of solvents, and by moisture in solvents or dirty filters. Leaky equipment, improper proportion of solvents, careless temperature control by the operators, or defects in the temperature control equipment, tend to give a high pour test.

After a prolonged period of operation, the plant is shut down and all tanks are unheaded, and a liquid gage is actually taken to remove any possibility of erroneous loss figures being compiled from the indicating gages.

The solvent dewaxing plant is capable of charging stocks over wide ranges of characteristics. The actual charge has consisted of untreated or treated and contacted wax distillate. Stocks used have been produced from three different crudes: viz., western Kentucky, Illinois, and Oklahoma (Seminole and Oklahoma City). Depending upon tests desired on the finished product, the pour point has ranged from 0° F. to — 35° F. The greater volume of running has consisted of stocks to be finished to — 5° F. pour. When untreated stocks are run, it is necessary to dewax to a — 10° F. to — 15° F. pour, to allow for rise in pour tests due to subsequent treating in order to produce finished oil of — 5° F. pour. However, when treated stocks are processed, the pressed distillate is run to a — 5° F. pour. In all instances the stocks have been vacuum-distilled wax distillate from either of the three above crudes or from any combination of the three.

Stocks which have been processed represent the entire range of wax distillate in these crudes. However, the cuts which are processed can be controlled in the initial vacuum distillation to keep the lubricating-oil production by grades within the sales department's requirements. By this method of operation it is possible to control, through primary vacuum distillation, the production of finished oils and to preclude any possibility of producing a surplus of any one grade.

The processing of various stocks is tabulated in Tables 1 to 5, inclusive. The wax distillates in each case were treated with 15 pounds per barrel of sulfuric acid, contacted with 10 pounds per barrel clay, solvent dewaxed, and vacuum-stilled to grade.

STOCKS

Tables 1 to 5, inclusive, show the wide range of stocks which can be processed; for example, stock "D" is a pressable distillate which was dewaxed in one filtering to a — 40° F. pour. Stock "A" is a wide-range wax distillate that includes all cuts from 115 Saybolt Universal viscosity at 100° F. to 117 Saybolt Universal viscosity at 210° F. Finished cuts from stock "F", which is a very narrow range of wax dis-

tillate, are from 61 Saybolt Universal viscosity at 210° F. to 145 Saybolt Universal viscosity at 210° F. Stock "E" is a re-run product.

Yields are controlled entirely by the balance between cost and values. In all instances yields can be brought up to 85 per cent to 90 per cent by using a higher solvent ratio. On low-cost crude and low-value products (low-viscosity oils) a ratio of three parts solvent to one part oil is probably the most advantageous balance. On the high-viscosity stocks four parts solvent to one part oil is satisfactory. However, on higher-priced crudes, a ratio as high as five to one is economically advantageous. Under these conditions yields of from 85 per cent to 90 per cent are obtained.

Rapid chilling has no practical effect on plant operation. At the Lawrenceville plant the stocks are chilled from 90° F. to filtering temperature in from one to three hours. Varying the rates of chilling has no effect on filtering rates.

The breadth of the cuts within the limits cited does not affect filtering except as to influence the pour point on cuts from re-running. This is shown in stocks "B" and "C", where the first cut and last cut of the re-run still are 5° F. higher in pour than the pressed distillate.

In general, it may be said that any wax distillate within the range of viscosity from 70 Saybolt Universal at 100° F. to 85 Saybolt Universal at 210° F., and a Tagliabue-Robinson color of one or more, is a satisfactory stock for solvent dewaxing.

Treated and contacted, or untreated raw, distillate can be processed equally well. Both stocks have been run through the Lawrenceville plant, although the present method is to run treated stocks. The reason for this is purely economic—although recent changes

TABLE 1
Tests on Wax Distillate

Stock	"A"	"B"	"C"	"D"	"E"	"F"
Gravity, deg. A.P.I.	23.6	24.0	25.0	30.1	Surplus	23.6
Flash point, deg. F.	445	425	370	295	stock	510
Fire point, deg. F.	515	530	450	350	from	585
Viscosity at 100 deg. F., Saybolt Universal	...	...	242	72	secondary	...
Viscosity at 210 deg. F., Saybolt Universal	65	70	...	...	distillation	76
Pour point, deg. F.	90	110	95	65		100
Conradson carbon, per cent	0.47	0.98	0.11	...		0.78

TABLE 2
Tests on Treated and Contacted Wax Distillate

Stock	"A"	"B"	"C"	"D"	"E"	"F"
Gravity, deg. A.P.I.	24.8	25.4	25.8	30.6	25.7	25.2
Flash point, deg. F.	460	475	420	325	340	510
Fire point, deg. F.	525	550	480	360	385	585
Viscosity at 100 deg. F., Saybolt Universal	...	...	238	73	115	...
Viscosity at 210 deg. F., Saybolt Universal	64	73	...	...	...	75
Pour point, deg. F.	95	105	90	65	0	100
Conradson carbon, per cent	0.35	0.58	0.07	...	...	0.40
Color, Lovibond—½-inch cell	60	90	20	...	...	35
6-inch cell	...	...	...	26	160	...

TABLE 3
Pressed Distillate

Stock	"A"	"B"	"C"	"D"	"E"	"F"
Yields, per cent	74.72	70	78	60	87	75
Solvent-oil ratio	3-1	3-1	3-1	3-1	3-1	4-1
Filtering temperature, deg. F.	—5 to —10	—5 to —10	—5 to —10	—50	—35	—5 to —10
Gravity, deg. A.P.I.	23.4	23.0	24.3	28.0	25.3	23.7
Flash point, deg. F.	455	485	415	330	355	505
Fire point, deg. F.	530	560	475	375	400	580
Viscosity at 100 deg. F., Saybolt Universal	...	...	324	82	100	...
Viscosity at 210 deg. F., Saybolt Universal	69	74	...	...	...	85
Pour point, deg. F.	—10	—5	0	—40	—35	—5
Conradson carbon, per cent	0.39	0.58	...	...	...	0.6
Color, Lovibond—½-inch cell	95	110	50	...	...	200
6-inch cell	...	...	...	200	125	...

TABLE 4
Yields Motor Oil Grades

Stock	"A"	"B"	"C" (Per Cent)	"D"	"E"	"F"
100 pale	8.0	1.0	25	...	...	...
S.A.E. 10	9.4	...	25	...	...	...
S.A.E. 20	13.5	17.0	25	...	...	...
S.A.E. 30	17.8	...	20	...	...	24
S.A.E. 40	22.6	45.0	...	...	...	15
S.A.E. 50	...	...	...	...	...	35
S.A.E. 60[1]	26.7	35.0	3[2]	...	...	25
Loss	2.0	2.0	2	...	...	1
	100.0	100.0	100	...	...	100

[1] Produced as a residuum on re-running.
[2] Run over caustic, base to fuel oil.
All the above yields and tests are on plant runs, except "D" which was run on the control plant.

TABLE 5
Tests on Finished Cuts

STOCK "A"

Grade	S.A.E. Grades						
	100 Pale	10	20	30	40	50	60
Gravity, deg. A.P.I.	25.7	24.0	23.9	23.5	23.2	...	22.6
Flash point, deg. F.	340	410	430	460	480	...	540
Fire point, deg. F.	385	465	495	525	560	...	620
Viscosity at 100 deg. F., Saybolt Universal	115	...	...	...	...	...	...
Viscosity at 210 deg F., Saybolt Universal	...	47	53	61	72	...	123
Pour point, deg. F.	—5	—5	—10	—10	—10	...	0
Conradson carbon, per cent	...	0.031	0.066	0.133	0.214	...	1.52
Color, Lovibond—½-inch cell	...	...	...	...	40	...	225
6-inch cell	160	180	180	210	...	...	...

STOCK "B"

Grade	100 Pale	S.A.E. 20	S.A.E. 40	S.A.E. 60
Gravity, deg. A.P.I.	25.0	23.5	23.8	20.8
Flash point, deg. F.	360	435	485	565
Fire point, deg. F.	410	500	570	640
Viscosity at 100 deg. F., Saybolt Universal	135	423	...	...
Viscosity at 210 deg. F., Saybolt Universal	...	...	77	148
Pour point, deg. F.	—5	—5	—10	0
Color, Lovibond—½-inch cell	...	...	...	210
6-inch cell	125	145	200	...

STOCK "C"

Grade	100 Pale	S.A.E. 10	S.A.E. 20	S.A.E. 30
Gravity, deg. A.P.I.	24.5	25.0	24.8	24.1
Flash point, deg. F.	375	410	435	485
Fire point, deg. F.	420	475	505	555
Viscosity at 100 deg. F., Saybolt Universal	138	233	363	715
Viscosity at 210 deg. F., Saybolt Universal	...	...	...	67
Pour point, deg. F.	5	0	0	—5
Color, Lovibond—½-inch cell	...	...	...	30
6-inch cell	45	55	140	...

STOCK "F"

Grade	S.A.E. 30	S.A.E. 40	S.A.E. 50	S.A.E. 60
Gravity, deg. A.P.I.	24.8	24.4	23.6	22
Flash point, deg. F.	460	505	535	570
Fire point, deg. F.	530	580	610	655
Viscosity at 210 deg. F., Saybolt Universal	61	74	86	145
Pour point, deg. F.	—5	—5	—5	0
Color, Lovibond—½-inch cell	...	37	40	200
6-inch cell	210	...	...	...

have revised the balance, and it is probable that the raw distillate will be dewaxed, re-run, and stock grades treated and contacted for finished oils. The method employed is an individual plant problem.

Pressed distillate can be controlled to be on test for motor oils in the entire range from S.A.E.-10 to S.A.E.-50 by single straight-line processing. Plants which have available bright stocks or neutral stocks for blending can, therefore, balance their production and eliminate the secondary re-running. At the Lawrenceville plant the entire motor-oil line is produced from a single cut of wax distillate, necessitating only segregation of grades in finished storage.

All stocks filter very readily at exceptionally high rates of filtration. Yields can be increased up to 85 per cent to 90 per cent on all grades by displacement wash or dilute solution, the controlling factor being the economic value of the additional oil recovered. On present price structures the displacement wash is not warranted for the slight additional amount of oil recovered.

SOLVENTS

Development of the control of solvent losses is a feature of the solvent dewaxing plant which has made it highly economical. The actual solvent loss at the Lawrenceville plant in mid-summer operation is 0.2 per cent of the quantity of solvent used.

The acetone used is commercial acetone, purchased in the open market. In the original operation industrial, pure commercial benzol was used. Gradual increasing of the viscosity of the wax-distillate charge has made it necessary to substitute non-corrosive, industrial, pure 90-per-cent benzol in order to prevent crystallizing of the benzol out of solution on four-to-one mixes. The price of both products is the same. The slightly higher end point of the 90-per-cent benzol offers no problems in separation from the pressed distillate.

As pointed out earlier in this paper, solvents are maintained under closed pressure storage in which no venting to the atmosphere is necessary. In addition, in the operation of the filters the gases used to drive the pressed distillate from the wax cake in the drying process in early operation were vented to the atmosphere, and caused excessive losses. In order to eliminate this loss, a flue-gas system was installed, and all gases circulated in the system.

The other source of loss in solvents in the distillation equipment has been eliminated by sealing the

receivers on the condensate from the solvent stills with an oil seal, providing 24-inch submersion. With this method a slight back pressure is held on the condensers, and any uncondensed vapors are absorbed in the seal. There are no non-condensable gases in the distillation. The seals are kept filled with stock being processed; and, when they have absorbed 5 per sent by volume of solvent, they are re-run along with the pressed distillate mix, and fresh charge in the seals is taken from the current production. We have found by this method that during extremely hot weather, when the temperatures of the solvents show as high as 115° F., no difficulties are encountered in solvent loss. It is usually necessary to empty the seals during hot weather about once a week. During cold weather, when condenser waters are cold, it is only necessary to empty the seals about once a month. Provision was made for making the outlets from these seals to the flue-gas system, but it has not been found necessary to do so.

The wax distillate from the treating and contact plant, or from primary distillation, usually contains a small amount of moisture—which, if permitted to stay in the system, would be accumulative and destroy to a certain extent the solvent action of the solvents. All of this moisture is found in the slack-wax cake, and shows up in the solvent recovered from the slack wax. When the amount becomes sufficient to show a cloud in the recovered solvent, it is pumped through a concentrated solution of sodium carbonate—which absorbs the moisture.

No unusual features of fire protection are necessary; safety steam lines are available in the pump rooms and chiller room. All motorized equipment in the vicinity of solvents is of explosion-proof type; all switches are oil-immersed.

The Lawrenceville plant has a charging capacity of 1200 barrels per day of wax distillate of 75-80 Saybolt Universal viscosity at 210° F., with a four-to-one mix and running to a — 5° F. pour. Processing stock of a viscosity of 200-250 Saybolt Universal at 100° F. for a —10° F. pour, with a three-to-one solvent ratio, the charging capacity is 1800 barerls of oil per day. These capacity figures are for net oil, and do not include solvents.

Oils produced by dewaxing a vacuum-distilled wax distillate containing the entire range of oils required for motor-car lubrication, with subsequent re-running to viscosity, have exceptional characteristics. The narrow-cut grades do not contain the more volatile neutral oil cuts nor high carbon-content stocks. This is shown in Table 6.

All equipment used in constructing and operating a solvent dewaxing plant is available in the open market. Standard ammonia, compression, or absorption plants are well suited for the refrigeration equipment. Due to the high percentage of refrigeration recovered by the exchangers, and to the fact that the chilling temperatures are moderate, investments and operating expense are at a minimum. The evaporating pressure with the ammonia plants is above atmospheric in producing all oils to —15° F. pour point. Operating the ammonia system on a positive pressure eliminates all necessity of purging and difficulties with high head pressures or infiltration of air into the ammonia system. Heat-transfer rates average between 20 and 30 B.t.u. per square foot per hour, per degree of Fahrenheit in the chilling system. These high rates of transfer reduce the investment required for chilling equipment. Filter rates average from 0.3 barrels of oil per square foot per day for the heavier distillate to 0.5 barrels of oil per square foot per day for the lighter distillate. Again, these rates are net oil content, and include the blowing and dumping time. Actual filtering rates are 45 per cent higher than the above figures.

There are no unusual maintenance or repair items in the operation of the plant. No corrosion troubles have been experienced in six years of operation. Distillation temperatures are moderate, and no pressures exceeding 45 pounds per square inch are used in the process except on the refrigeration equipment.

SUMMARY

Solvent dewaxing with the benzol-acetone solvent is applicable to all distillate stocks, including a wide-cut wax distillate carrying all grades from neutrals to bright stocks, or close-cut neutrals and close-cut motor oil stocks.

The process is adaptable to changing requirements of pour test of finished products from 0° F. to —40° F., without substantial change in equipment or method.

Finished dewaxed oils produced by the process are free from wax cloud.

The process is adapted to installation in any locality or climate. The refrigerating or condensing equipment requires no special cooling waters.

TABLE 6

Grade	S.A.E. Grades 10	20	30	40	50	60
Gravity, deg. A.P.I.	24.5	24	23.8	23.7	23.0	22.6
Flash point, deg. F.	405	425	455	480	505	540
Fire point, deg. F.	460	485	520	555	585	620
Viscosity at 210 deg. F., Saybolt Universal	47	52	61	70	91	117
Pour point, deg. F.	—5	—5	—5	—5	—5	0
Cloud point, 0 deg. F.	None	None	None	None	None	None
Carbon residue, per cent	0.05	0.06	0.19	0.24	0.65	0.94
Color, Lovibond—½-inch cell	...	...	...	40	70	140
6-inch cell	140	140	250	...	...	...

Dewaxing Oils *in* Propane Solution With Self-Refrigeration

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A NEW process of dewaxing oils has been developed which involves solution of the oil in a normally gaseous solvent, such as propane, under pressure, followed by adiabatic evaporation of part of the solvent to self-refrigerate for crystallization of wax, and distillation of the remaining solvent after separation of wax from the chilled solution. Preliminary investigation of this process showed it to be characterized by high filter rates or wax-settling rates, accompanied by high yields of dewaxed oil with a low differential between wax-separation temperature and pour point of finished oil, and applicable to all types of oils which are now commonly dewaxed. A plant involving the principles outlined above has been constructed which has a charging capacity of 55,000 gallons of wax-bearing oil daily. Operation of this plant has been very satisfactory, and has established the process as one of marked commercial significance.

TULSA, OKLAHOMA MAY 17-19, 1933

THROUGH years of dewaxing experience the petroleum industry has adopted generally three methods of dewaxing for the production of relatively low-pour-test oils from wax-bearing crudes. These processes are commonly known as: 1, paraffin-distillate pressing; 2, cold-settling; and 3, centrifuging. It has been recognized for some time that each of these processes has its limitations as to the type of oil which can be successfully dewaxed. The first has been limited either to very light distillates or to sharply fractionated medium-viscosity distillates, while the latter two have been limited to residual oils of relatively high viscosity. These limitations have resulted in the necessity of equipping a refinery with two different processes when a complete line of lubricating oils is desired and none of the processes is well adapted to dewaxing heavy distillate oils desirable for making motor oils of low-carbon residue. In addition to the above limitations the three processes have been subject to little improvement in recent years, and are known to be relatively costly operations.

The research laboratory of this company has for several years devoted considerable attention to the development of improved dewaxing methods in an attempt to develop a more flexible and less costly process. In the course of these investigations it was suggested that a process based upon the following steps offered excellent possibilities of accomplishing the desired aim.[1] The proposed process included:

1. Solution of the wax-bearing oil in a liquefied gas, such as propane or butane, to produce a homogeneous solution under pressure.

2. Adiabatic evaporation of part of the low-boiling solvent, thus producing a low temperature and crystallizing the wax.

3. Separating the wax from the solution, either by filtration or settling.

4. Distillation of the remaining solvent from the two fractions.

Such a process should have the great advantage of self-refrigeration instead of indirect heat transfer, should give solutions of low viscosity, and should permit the growth of large crystals. Moreover, the comparative ease with which these light solvents can be removed after dewaxing should should minimize color loss in the process.

An extensive investigation of this process has fully justified the early anticipations, and has resulted in the construction of a plant charging 55,000 gallons of wax-bearing oil daily. Operation of this plant has confirmed the results of the smaller scale experiments, and has established the process as one of marked commercial significance.

PRELIMINARY EXPERIMENTAL WORK

It was to be expected that solutions in propane or butane would be very fluid and low in density to aid settling; but it was feared that propane would have too high a solvent power for wax, since in comparing various naphthas the lighter the naphtha, the greater the wax solubility. Accordingly, early experiments were directed at a determination of the properties of oil solutions at dewaxing temperatures to afford data for quantitative estimation of the merit of the process. Thus the density, viscosity, and wax-settling rate, as well as cold-test differential[2] on dewaxing,

[1] A number of patents have been applied for on the features of this process.

[2] The difference between the temperature of filtration, or settling of the solution, and the pour point of the finished oil. It is a function of the concentration which can be employed and the solubility of wax in the solution.

TABLE 1

Properties of Propane, Butane, and Naphtha Solutions of Oil

PART 1—SPECIFIC GRAVITY AND VISCOSITY

Solution		Specific Gravity at —10 Deg. F.		Approximate Viscosity (Poises)			Settling Solution Tendency*		
Per Cent S.A.E.-50 Oil	Per Cent Solvent	Naphtha Solution	Butane Solution	Naphtha Solution	Butane Solution	Ratio	Naphtha Solution	Butane Solution	Ratio
15	85	0.813	0.667	0.025	0.005	5.0	5.32	55.9	10.5
25	75	0.828	0.700	0.047	0.009	5.2	2.51	27.4	10.9
35	65	0.841	0.733	0.101	0.018	5.6	1.04	11.8	11.4

*Density of wax minus density of solution, divided by viscosity of solution.

PART 2—SETTLING RATES

SETTLING OF WAX-BEARING S. A. E.-50 OIL IN GLASS GRADUATES

(See Text for Description of Conditions of Experiments)

Elapsed Time (Hours)	Per Cent Clear Solution			
	25 Per Cent Oil—75 Per Cent Solvent		15 Per Cent Oil—85 Per Cent Solvent	
	Naphtha†	Propane	Naphtha	Propane
0.25	0	10	..	18
0.50	0	30	..	48
0.75	0	42	..	69
1.5	0	66	..	80
2.0	0	69	2	81
5.0	0	..	6	..
10.0	0	..	14	..
25.0	0	..	35	..
30.0	0	..	36	..

†80 per cent naphtha showed only 26 per cent clear solution after 30 hours.

were obtained on propane and butane solutions of oil and compared with the same properties of solutions of the oil in a naphtha commonly used in dewaxing. These comparisons indicated very marked advantages for the use of these low-boiling hydrocarbons in comparison with naphtha.

Some of the data obtained are shown in Table 1, Part 1 shows the results of measurements of specific gravity and approximate viscosity of solutions of an S.A.E.-50 distillate oil in butane and in naphtha at —10°F. It will be noted that the butane solutions are much less viscous than the naphtha solutions. Assuming the same crystal characteristics and filtering pressures, filter rates will, in general, be inversely proportional to viscosity. In this case butane shows a marked advantage over naphtha as shown by the ratios of viscosities. Relative settling tendencies of wax in these solutions are also indicated in Part 1. These are computed on the assumption of adherence to the conditions required by Stokes law. It will be noted that a very marked advantage is indicated for the butane solutions.

Settling tendencies were directly confirmed by such data as are shown in Part 2. For these experiments propane solutions of the S.A.E.-50 oil were self-refrigerated at a rate of chilling 3°F. per minute. When the temperature reached —40°F. (atmospheric pressure) a portion of the solution was immediately withdrawn from the steel vessel into a glass graduate immersed in a bath of acetone and solid carbon dioxide. The per cent of clear solution as a function of time was then recorded as the solution settled.

The naphtha solutions were made up in graduates, and these were immersed in a bath of naphtha. These solutions were chilled at the customary slow rate of 2°F. per hour. Chilling to 0°F. was carried out by placing bath and contents in a cold room; from 0°F. to —40°F. they were chilled by slow addition of solid carbon dioxide to the bath. At —40°F. the solutions were very gently agitated and then allowed to settle.

These data in Part 2 (Table 1) confirm the rapid settling tendency indicated in Part 1. The wax settles extremely rapidly in propane solution, even though crystallized at refrigeration rates which are extremely high in comparison with those commonly considered necessary for good settling. It will also be noted that in propane solution the wax settles to a sufficiently compact mass to afford a good yield of dewaxed oil, whereas in naphtha settling is impractical on this oil because of the low yield of dewaxed oil.

Careful measurement of the A.S.T.M. pour point of the oil recovered from the clear solutions in the experiments recorded in Part 2 (Table 1) showed that, at equal solvent concentrations, the oil dewaxed in propane was 5°F. lower in pour point than that dewaxed in naphtha (—10°F. as compared with —5°F.). This result was so different from that which was expected from consideration of published data on the solubility of wax in naphthas of various molecular weights that this point was followed up further by experiments on solubility of wax in propane, butane, and several higher boiling petroleum fractions. These experiments gave further weight to the indicated lowered pour point. The results of these measurements are shown in Figure 1, where the solubility of 120°F.-melting-point wax in propane, butane, and several naphthas is shown as a function

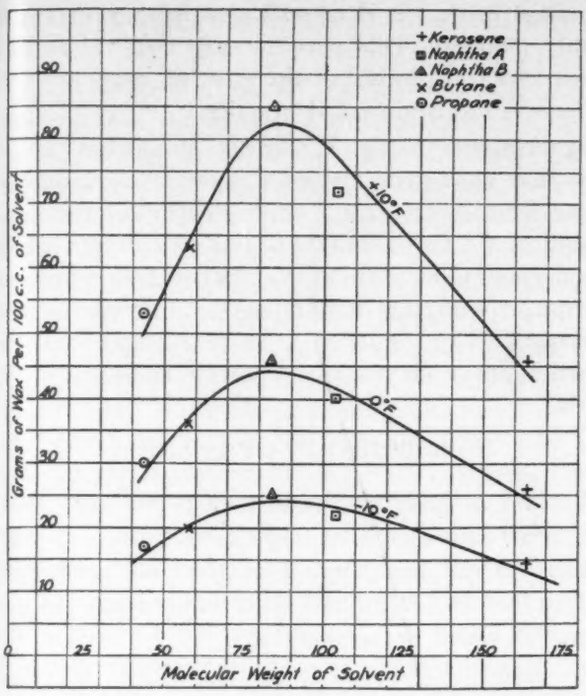

FIGURE 1
Solubility of 122-Degree-Melting-Point Wax in Various Solvents.

of molecular weight. It will be noted that the curves pass through a maximum, and this accounts for the lowered pour point obtained in the case of dewaxing in propane.

As pointed out above, the data of Table 1 and other similar data indicated probable high filter rates for the propane and butane solutions. Accordingly, rates of filtration were obtained with a small filter leaf, using moderate pressures; and were found to be very high. These experiments further added to the possibilities of the process.

DEVELOPMENT OF PROCESS

These earlier data indicated that the process was probably extremely flexible, and very probably applicable to all types of oils and to either filtering or settling operations. This was confirmed in the experimental work carried out in the development of the general process of dewaxing in solution in light hydrocarbons. The process has been carried to its fullest development, however, in a filtering type of operation. Accordingly, the present paper emphasizes this method.

The immediate use for the process, as far as this company is concerned, was for dewaxing distillate motor oils (S.A.E. 10 to 60 grades, inclusive). Accordingly, the first large-scale experiments were directed at developing a process for handling them.

The apparatus used is shown diagrammatically in Figure 2. The insulated pressure vessel **A**, of about 10 gallons capacity, is shown connected to the press **B** by means of flexible tubing **C**, while flask **D** is arranged to collect filtrate. A second vessel, similar to **A**, was also available, and was used for experiments on washing the cake on the leaf with cold hydrocarbon solvent.

The apparatus was operated in a cold room to avoid radiation as far as possible. In making a run the pressure vessel was removed, and a weighed amount of oil introduced through the connection for the flexible tubing. The light hydrocarbon solvent (propane or butane) was then weighed into the drum from a second pressure vessel, and the contents of the drum **A** warmed by admitting steam to the coil **E**. The drum was then placed on the trunnions **G**, and the solution made homogeneous by rocking the drum. It was then connected to a vent line at **H**, and chilling obtained by evaporation of a portion of the solvent. Pressures and temperatures during the chilling cycle were observed by means of the gage **J** and thermometers **K**. After chilling, the drum was connected to the press (containing a leaf of 0.6 square feet area, covered with canvas), and filtration was carried out under pressure of air applied to the drum **A** through the connection **H**. The press was protected from radiation by immersion in a bath (not shown) of kerosene refrigerated with solid carbon dioxide. Concentration of solution and quantity of oil filtered were determined by weighing the vessel **D** before and after evaporation of the solvent. When washing the cake, the second vessel was connected to the press in a manner identical with that for **A**, and the cake was washed with solvent at the temperature at which the filtration was carried out.

First experiments were carried out on a Mid-Continent distillate having a viscosity (Saybolt Universal) of 92 seconds at 210°F. Experiments with both propane and butane indicated the former to be more practical for producing the pour point desired (0°F.).

Experiments on the effect of rate of chilling on filter rate showed that rates of chilling as fast as

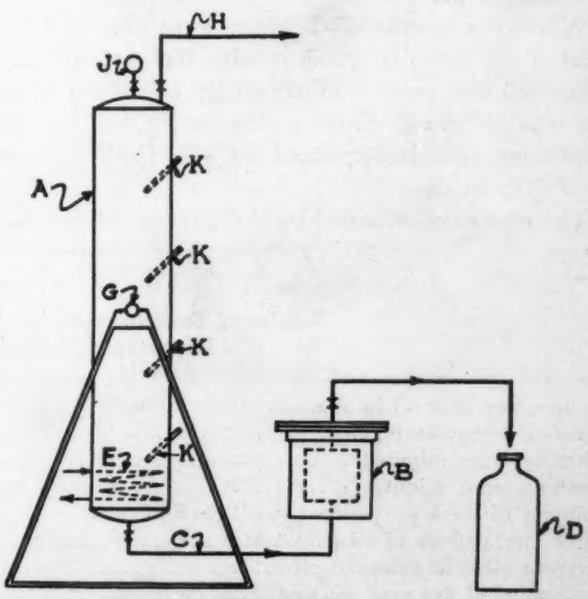

FIGURE 2
Experimental Dewaxing Apparatus.

5°F. per minute gave remarkably fast filter rates. On the other hand, there appeared to be a practical limit to the rate of chilling, because instantaneous chilling from 95°F. to —40°F., as is obtained by throttling the solution from high pressure to atmospheric through a valve, lead to unfiltrable suspension of very fine crystals. Rates of chilling intermediate between the above limits were not tried, because the former is as fast as can reasonably be obtained when chilling by a batch operation; whereas the latter seemed to limit the possibilities of application of flash chilling. Further confirmation of this was obtained when it was found that a small amount of flash-chilled mixture added to a mix of good filtering characteristics appreciably lowered the filter rate obtainable.

The effect of concentration of solution on filter rate, yield, and pour point of dewaxed oil were also studied. These data, together with those obtained from experiments on washing, gave basic information for the design of a plant. Typical data obtained are shown in Table 2.

It will be noted from the results recorded in this table that filter rates of several gallons per filtering hour per square foot of filtering surface are readily obtainable at very low filtering pressures. These high rates were consistently obtained on this and other oils of higher and lower viscosities. Also, the yields of dewaxed oil were notably good. With a moderate amount of washing the yields approached very closely the maximum obtainable. Analyses of the wax cakes obtained consistently showed oil content to be as low as about 30 per cent. From oils containing 12 to 14 per cent wax, yields of 80 per cent dewaxed oil were readily obtained—which is distinctly better than obtainable by most commercial processes. Very low pour points, as shown by Table 2, and lower ones in the case of less viscous oils were obtained with comparative ease.

While the results of Table 2 were obtained on a treated oil, equally good results were obtained on untreated distillates. Substantially complete dewaxing was obtained. Thus, a dewaxed S.A.E.-50 Mid-Continent distillate poured at —5°F. before and after acid treating.

The wax cake obtained by this process as described is unique in that it is of such consistency that it is readily pumped. This permits easy removal from a press, and contributes to the ease of application of the process to commercial practice.

Experiments using apparatus somewhat larger than that shown in Figure 2 were also conducted. These were directed at a determination of the practicability of a vertical press of our own design which was deemed to be particularly suitable to the process. Operation with this larger press (14 square feet of filtering surface) showed it to be suitable, and the experiments confirmed the expectations of the earlier work.

DESCRIPTION OF PLANT

A plant embodying the principles outlined above has been constructed at the Wood River, Illinois, refinery of this company. This plant has a charging capacity of 55,000 gallons daily, and it has been in operation since September 1932.

A somewhat simplified flow diagram of the plant and process as designed is shown in Figure 3.

Propane from the storage vessel **A** is mixed with oil from the tank **B,** and the combined stream pumped through a heater **C,** wherein the mixture is heated with steam to a temperature of about 130°F. The combined stream is then discharged into one of the chilling vessels **D**, until the drum is about three fourths full—at which time the stream is diverted to another chilling vessel. Chilling in the vessel is accomplished largely by evaporation of a portion of the propane, but is aided somewhat by the slow introduction of cold propane (—40°F.) from tank **M,** which has been used to wash the filter cake on the leaf. The evaporated propane is compressed by compressor **E,** and is condensed in **F** to return to the storage vessel **A.** Following the chilling the cold mixture is discharged to one of the storage vessels **G** which acts as a reservoir for the pump **H.**

In operating the plant the chilling drums are charged in rotation; thus one drum may be filled while the second is being chilled; the third being ready for discharging to the cold-oil storage drums. A complete cycle of charging and chilling requires about 90 minutes. Final chilling temperature is

TABLE 2

Results of Experiments with Apparatus and Method as of Figure 1
Dewaxing S. A. E.-50 Oil in Propane Solution*

Volume, per cent oil in solution after chilling	17	27	35	48
Filtering temperature, deg. F.	—40	—40	—37	—47
Filtering time, minutes	10	15	20	20
Washing time, minutes	10	15	20	20
Volumes of wash per volume of oil charged	3	2.5	2.5	2.5
Filter rate, gallons of oil (in filtrate) per square feet per hour	4.3	3.0	1.6	0.25
Per cent yield of dewaxed oil	..	83	75	..
Pour point of dewaxed oil, deg. F.	—5	—5	—10	—15

*In all experiments the oils were dissolved in propane at 95 F., self-refri gerated at a rate of 3°F. per minute, and filtered under 50 pounds pressure.

—40°F., and filtration is carried out at this temperature.

The chilled mixture is pumped under 50 pounds pressure into the presses **J** through the bottom, the filtrate passing to the storage tank **K.** When the desired quantity of mixture has been filtered, the excess mixture in the presses is drained to the storage vessel **G** with the aid of propane vapor (at about 10 pounds pressure) introduced at the top of the press. Cold propane is then pumped into the presses from the storage vessel **L.** This propane has been cooled by heat exchange with the outgoing filtrate and by self-evaporation. When the desired quantity of cold propane has been pumped through the filter cake into tank **M,** the excess is drained from the press to the storage vessel **L.** After having been washed thus, the wax cake is discharged by means of a back blow of propane vapor through the leaves. By this operation the cake is discharged through the conical bottom section of the presses into the screw conveyor **N,** which carries it to the wax storage tank **O.**

Propane is recovered from both filtrate and wax by distillation. The oil is pumped into the distillation system **P,** where the bulk of the propane is removed by distillation under 200 pounds pressure—using closed steam as a heating means. Propane is condensed in the water-cooled condenser **F,** and returned to the storage vessel **A.** From the 200-pound section the hot-oil solution containing a small amount of propane is throttled to atmospheric pressure and stripped with steam. This steam is condensed in a jet condenser **Q,** and the uncondensed propane is re-compressed and condensed in **F.** The dewaxed oil is finally stored in tank **R.** A similar system for separating propane from the wax is shown at **S,** the wax being finally stored in tank **T.**

The flow diagram does not show in all cases the number of units for each type of equipment. Specific exceptions are the compressors and filters. The plant as constructed comprises eight presses (operated in two batteries of four each) and three compressors. The two batteries of presses have separate charging pumps and lines. The service of the compressors will be described later.

The presses are vertical cylindrical vessels, each containing 11 canvas-covered rectangular leaves. The bottom section of the press is conical, connecting to the screw conveyor; and the top is equipped with a dished head, which is flanged to facilitate occasional removal for repairs. Discharge from each leaf may be diverted through a sight glass for observation when such seems necessary from observation of the master sight glass.

The compressor equipment is housed in one building; while the presses, pumps, and control equipment are housed in the second building. Chilling vessels, as well as storage vessels and distillation equipment, are unhoused. The compressor equipment comprises three separate compressors, one of which operates at a variable suction pressure and handles the propane evaporated during the chilling operation. A second compressor is connected to all tanks containing propane at atmospheric pressure (storage tank for chilled solution, fresh wash tank, used wash tank, filtered solution tanks, and the wax tanks). This compressor also handles the vapor evolved on evaporation of propane for production of cold wash. A

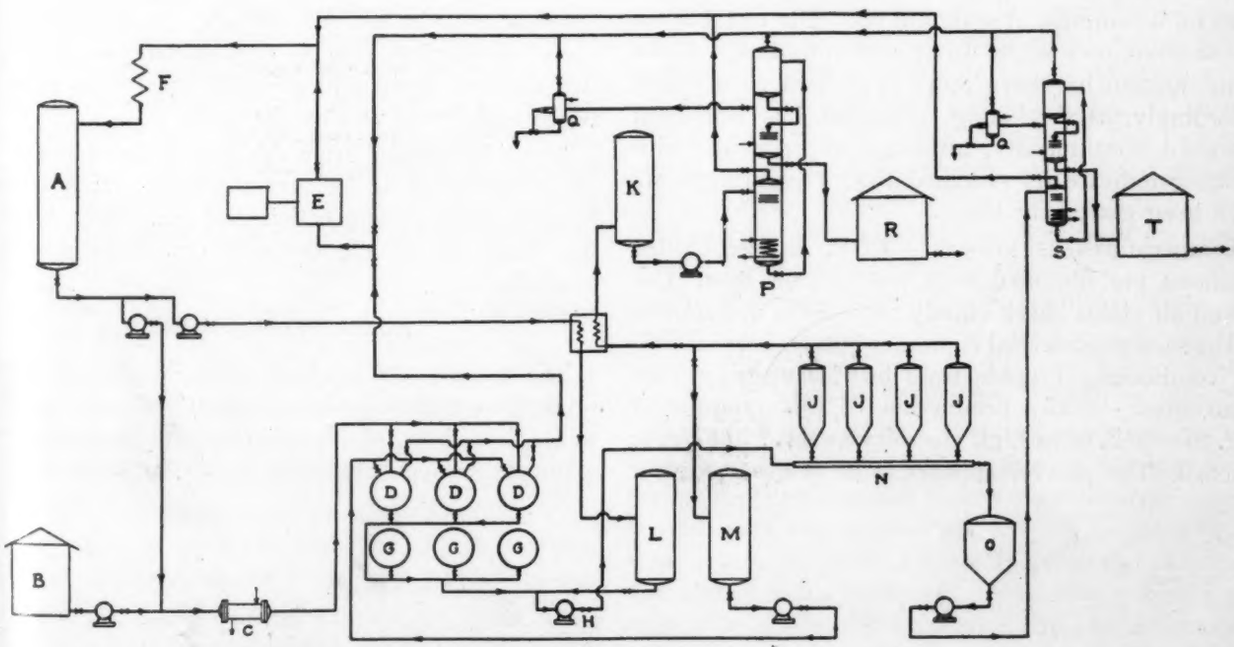

FIGURE 3

Flow Diagram of the Wood River Dewaxing Plant.

third compressor acts as a stand-by, and is suitable for either service.

The pumps, presses, and control rooms are housed in a three-story building. The pumps occupy the first floor; while the presses occupy the second floor, and extend a short distance through the third floor to make the top connections readily available there. The control room for the chilling operation is located on the first floor, while the control room for the filtering operation is located on the second floor.

In laying out the plant considerable attention was paid to centralization of control. This has been accomplished through the use of hydraulically-operated valves at the points requiring frequent operation.

At present one operator is required in the compressor building, one operator in the chilling control room, one operator in the press control room, two operators look after the pumping operations, while a foreman has general charge of the operation. This requirement can, no doubt, be reduced by one or two men as further experience is gained.

The buildings are exceptionally well ventilated; and the equipment is, of course, designed to prevent leakage of propane and formation of sparks. The buildings can also be rapidly flooded with steam. While the operation might have been considered hazardous a few years back, the industry's experience in operation of absorption plants lends assurance to the probable comparative safety of the dewaxing process.

PLANT OPERATION

The plant has operated with great ease, and within a few weeks of its start it reached a production greater than the designed capacity, although filter rates on a commercial scale did not quite equal those on the laboratory scale. In operation to date, volume of production has been more important than yield; accordingly, the washing operation has not been practiced continuously, although experiments with washing indicate its practicability. Operating costs have been extremely low.

Temperatures as low as —45°F. on the chilled solutions are obtained with astonishing ease. Dewaxed oil yields check closely with those determined on the semi-commercial equipment under corresponding conditions. Trouble from leaf-leakage is a rare occurrence. Steady production of oils pouring at 0°F. to —5°F. of as high viscosity as S.A.E.-60 grade is usual. The process appears to be in every respect a very marked advance over the generally accepted dewaxing processes.

OTHER APPLICATIONS

While the foregoing description places considerable emphasis on dewaxing distillate oils of viscosities ranging from those suitable for S.A.E.-20 to those suitable for S.A.E.-60 motor oils, it should also be pointed out that the process is applicable with equal advantages to dewaxing oils outside this range, and to residual oils as well. Small-scale experiments (Figure 2) have been carried out on oils from other crudes, on residual oils such as are used for production of bright stocks, and on oils of various degrees of refining; and these experiments show that the process is equally applicable in all cases. Thus, for example, steam-refined stocks filter readily, giving as high filter rates as are shown above for distillate oils. Pour-point depressors have been tried in the filtering type of operation, and in some cases give higher filtering rates and higher yields before washing.

While considerable emphasis in this paper has been placed on the filtering operation as of Figure 3, this is done only because the process has been carried to more complete development along these lines. Experiments being conducted at the present time indicate that a continuous process of filtration, using equipment particularly suitable to the properties of the solutions, can be readily developed to give results equally as good as, and probably better than, those described herein. Continuous chilling methods have also been experimentally investigated, and some of these show good promise of application. Moreover, a modification of the process makes it possible to dewax and remove all asphalt from residual oils in one operation. Thus, by settling reduced crudes in propane or butane solution very good yields of dewaxed and asphalt-free oil are obtained. By settling at two different temperatures fairly good separation between asphalt and wax can be made.

It will be realized from this description that this development offers to refiners a process which is more flexible, easier of application, and less costly in operation than any of the dewaxing processes previously available.

ACKNOWLEDGMENT

The authors are indebted to H. V. Atwell for the original suggestion for investigation of this process, and to R. E. Wilson for his many helpful suggestions and enthusiastic support throughout this development.

Centrifuge Dewaxing *With* Trichlorethylene

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ASIDE from paraffin distillate, the dewaxing of those fractions of a crude oil from which lubricating oils are made has been rather difficult, and has been one of the most expensive steps involved in the production of low-pour oils. The original cold-settling method for pour-point reduction, because of its high cost and uncertainty of result, was eventually replaced by centrifugal dewaxing, which gave greater reductions in pour point and increased yields with lower investment and manufacturing costs. Considerable work has been done in recent years on the use of filter aids and solvents, all with the idea of developing a process which would give satisfactory pour points, and which at the same time would also be cheaper in operation and investment than the centrifuge dewaxing method generally used.

TULSA, OKLAHOMA MAY 17-19, 1933

DURING the past six or seven years, the Separator-Nobel (S-N) Company of Stockholm, Sweden, has been experimenting with a centrifuge for use with heavy solvents, and has now developed this machine to a point where it is being offered to the petroleum industry for dewaxing. The machine is built according to Separator-Nobel specifications by the Swedish De-Laval Company; and, while of a construction somewhat similar to the standard machines made by this company, has a special bowl which permits the discharge of the petrolatum from the center of the bowl and of the bright stock from the periphery—the reverse of the centrifugal process using naphtha as a diluent. This special bowl design is necessary due to the fact that the solvent—trichlorethylene—in which the oil is dissolved has a high specific gravity. Because of the great difference between the specific gravities of the solvent and oil it is possible to operate the machines at slower speeds than necessary with naphtha dilution, or from 8000 to 9000 r.p.m. against 15,000 to 17,000 r.p.m. for the super-centrifuge.

The advantages claimed for the S-N dewaxing process are that the machines will give greater throughput of dewaxed oil per machine than the usual methods. Lower dilutions of solvent, higher chilling rates (10 to 15°F. per hour), and a smaller spread between the final pour point of the finished oil and the centrifuging temperature are also claimed. These factors would permit a considerable reduction in the volumetric capacity of the plant, and also in the refrigeration required. Further advantages of the solvent are that it is non-flammable which, consequently eliminates fire hazards. Its high specific gravity and immiscibility with water permit storage under a covering layer of water, thereby reducing evaporation losses in tankage to a minimum.

A pamphlet has been prepared by the Roessler and Hasslacher Chemical Company giving the physical properties and uses of trichlorethylene; and, in an article published by the same company in *Ind. Eng. Chem.*, October, 1932, p. 1164-8, the stability of this solvent and its corrosive effects are quite thoroughly discussed. The following quotation is the summary of this article:

"Trichlorethylene does not decompose in darkness. It is not decomposed in light unless oxygen is present. The presence of traces of certain anti-oxidants prevents the decomposition in light.

"Trichlorethylene does not decompose on heating up to 130°C. It may decompose on heating in the presence of oxygen unless anti-oxidants are present.

"Trichlorethylene does not hydrolize. It is only slightly affected by ferric chloride. The ordinary metals do not catalyze decomposition of trichlorethylene. Trichlorethylene is not corrosive if anti-oxidants are present; even in the absence of these substances its corrosive effect is small."

The physical properties of trichlorethylene are shown in Table 1.

EXPERIMENTAL WORK

Since the sponsors of the S-N machine claimed that the separator was capable of giving large throughput with stocks of low wax content, experimental work was carried out on such an oil. Operation on a stock of this type is, in general, discontinuous; and it is only possible to secure continuous operation by artificially increasing the petrolatum concentration. Although primary interest was in low-petrolatum-content oils, additional tests were run on stocks which are currently handled by other dewax-

TABLE 1

Formula	$C_2H\ Cl_3$
Molecular weight	131.4
Color	Water white
Specific gravity (Referred to water at 39 deg. F.)	Temperature (Deg. F.) / Specific gravity
	32 — 1.4996
	59 — 1.4762
	86 — 1.4514
	113 — 1.4262
	139 — 1.3997
Pounds per gallon	12.25
Viscosity	0.550 centipoises at 77°F.
	0.446 centipoises at 122°F.
	0.371 centipoises at 167°F.
Boiling point	188°F.
Freezing point	—126°F.
Coefficient of expansion	0.001193 at room temperature
Heat of vaporization	104.5 B.t.u. per lb.
Specific heat (liquid)	0.2586 B.t.u. per lb. per deg. F.
Solubility of water in trichlorethylene	(86°F.)
	0.017 g. per 100 at 50°F.
	0.035 g. per 100 at 82°F.

ing methods. In Table 2 will be found results of typical runs at varying dilutions and chilling temperatures on several different feed stocks.

From the foregoing tabulation it may be readily seen that the throughput per machine is very high for oils of low wax content, diminishing as the petrolatum increases. It will also be noted that in the former case the spread between chilling temperature and pour on the finished oil is considerably less than is the case with high-wax-content stocks. Another interesting point is that the machine handled stocks which had not been completely refined, giving about the same throughputs as with completely refined stocks. Runs 6 to 9, inclusive, were made on an acid-treated, neutralized, reduced, and filtered stock; whereas runs 10 through 12 were made on a stock handled in a similar manner, except that it was not filtered prior to centrifuging. It has been found that dewaxed oils produced by this machine have a cloud point quite close to the pour point, the difference being about 5°F.

The experimental work on this machine, of which the above data represent only a part, has shown rather definitely that the following conclusions may be drawn:

1. In general, the Separator-Nobel centrifuge will dewax oils which can be handled by the usual centrifugal means, showing up to advantage on oils of low wax content and undecolorized stock.
2. The S-N dewaxing method uses somewhat lower solvent dilutions than processes employing naphtha as the diluent.
3. At any given dilution, the yield of dewaxed oil can be increased by taking lower throughputs.
4. For a given throughput and pour, yields of dewaxed oil usually increase with increased oil dilution.

PLANT DESIGN

The design of equipment for carrying out the process can be substantially the same as that for the commonly known centrifugal dewaxing plant. Actually, many improvements over the older type units have been incorporated in S-N centrifuge plants designed to date.

The low dilution and high allowable chilling rate permit the use of much smaller chilling drums, giving a shorter hold-up in the system. Consequently, when charging stocks the time required for the change and the contamination involved are greatly reduced. With these conditions, it is apparent that continuous chilling should be possible. Continuous chilling shows many advantages over batch chilling, including a lower plant cost (about 20 per cent lower), a smaller requirement of solvent on hand (about 50 per cent lower), simplified operation, a greater refrigeration recovery and, consequently, a smaller refrigerating plant. The operating cost of a continuous chilling plant is estimated to be about 15 per cent lower than that of a batch system. The above facts clearly indicate that batch chilling should not be considered.

In designing plants for high-pour feed stock, the trichlorethylene should be heated to about 120°F. in

TABLE 2

Stock	Gravity (Deg. A.P.I.	Saybolt Viscosity at 210 Deg. F.	Pour Point (Deg. F.)	Dilution (Oil to Trichlorethylene)	Chilling Temperature (Deg. F.)	Pour Point Bright Stock (Deg. F.)	Spread Between Chilling Temperature and Pour Point (Deg. F.)	Yield Bright Stock (Per Cent)	Barrels Per Day Per Machine
1. Reduced distillate	25.4	119	30	50:50	—25	2	27	95.2	84
2. Reduced distillate	25.4	119	30	50:50	— 3	10	13	97.2	116
3. Reduced distillate	25.4	119	30	50:50	0	12	12	97.8	116
4. Reduced distillate	25.4	119	30	55:45	1	20	19	98.2	110
5. Reduced distillate	25.4	119	30	55:45	0	20	20	98.2	102
6. Bottoms	24.3	135	95	40:60	—24	20	44	87.1	52
7. Bottoms	24.3	135	95	45:55	—19	22	41	87.8	53
8. Bottoms	24.3	135	95	50:50	—25	28	53	85.8	66
9. Bottoms	24.3	135	95	55:45	—25	28	53	82.7	53
10. Bottoms	23.8	140	95	40:60	—25	12	37	86.5	60
11 Bottoms	23.8	140	95	40:60	—20	12	32	87.0	59
12. Bottoms	23.8	140	95	40:60	—14	20	34	88.7	49
13. Bottoms	26.5	65	80	45:55	—18	40	47	89.0	41
14. Bottoms	26.5	65	80	40:60	—25	34	59	85.1	38

a commercial exhaust-steam pre-heater and pumped through a mixing column with the feed and then through a commercial cooler in which the solution should be cooled to about its pour point. The solution should then flow through the chillers, entering at the top and leaving at the bottom to prevent heat convection currents. The chiller volume should be based on a chilling rate of approximately 12°F. per hour. It is probable that higher chilling rates may be permissible; however, this fact has not been definitely determined. Actually, much higher chilling rates are not possible with the internal coil-type chiller, as the coil surface required fixes the minimum size of the tank and, thus, sets the maximum chilling rate at from 10° to 15°F. per hour. The chillers should be equipped with agitators in the top. The last chiller should be slightly elevated, and the level maintained just below the top by means of a level controller operating the feed pump. The solution can then flow from the last chiller to the centrifuges with no intermediate feed tank. Connections should be provided on each chiller, so that the solution may be pumped from one chiller to any other chiller.

The centrifuges are totally enclosed; and, accordingly, very little trichlorethylene vapor should be present in the centrifuge room. The petrolatum is melted in the centrifuge by means of closed exhaust-steam coils. This eliminates the usual petrolatum-water settling tanks and hot-water circulating system.

In view of the simple operation of both the centrifugal plant and the solvent-removal still, it is feasible to have these two units operating integrally. This procedure eliminates the intermediate storage tanks, and thereby decreases handling and evaporation losses as well as the quantity of solvent necessary in stock. For feed stocks having a small percentage of perolatum, the petrolatum dicharged from the centrifuge may be stored and run into the solvent-removal still when the centrifuge plant is down. However, for feed stocks containing reasonably large percentages of petrolatum, a separate petrolatum solvent-removal still should be used.

The still should be designed for exhaust-steam heating, so as to prevent a high-film temperature; and the maximum temperature to which the solvent is subjected should be 230°F. The solution should be pre-heated to about 165°F. by means of the overhead solvent vapors, and then further heated to 230°F. with steam in a special shell-and-tube vaporizer and flashed into the tower. Between 80 per cent and 90 per cent of the solvent present (depending on the mol per cent in the solution) will be vaporized in this heater. The tower need have only entrainment baffles above the point of flash, but should have about 10 bubble-cap trays below this point. Exhaust steam (about one pound per gallon of oil) should be used in the bottom of the tower as a stripping medium. In view of the large quantity of solvent remaining in the oil at the point of flash, some auxiliary heating means must be provided just below this point to supply the required latent heat of the solvent and preevnt the condensation of steam. The solvent-free oil from the bottom of the tower should be flashed into a vacuum drum for the removal of entrained moisture.

The still for the petrolatum should consist of a packed tower and a small feed vaporizer. Condensation of steam in this tower is permissible; hence no auxiliary heater is required. The over-head solvent vapors and steam should discharge to the bright stock-still over-head condenser.

If necessary, the equipment could be operated under a slight vacuum to keep a lower temperature; however, atmospheric operation is preferred, as it will give lower solvent losses.

The actual cost of building a plant for using this process is entirely dependent upon the stock to be handled, geographical location, as well as upon the chilling facilities provided—i.e., batch or continuous. In Table 3 will be found a comparison of the utility requirements for two typical plants of approximately 400 barrels per day of undewaxed oil charged. In the one case the dilution is low, as the stock is of low wax content (2 to 3 per cent), and the solvent-oil mixture is only chilled to 0°F.; whereas in the second instance with a 20-per-cent wax concentration there is a higher solvent dilution, and the solution is chilled to a temperature of —30°F. Continuous chilling is assumed in both plants, and in the first this is accomplished by means of water, dewaxed solution, and brine; while, in the second plant water, cold solution, and direct expansion of ammonia are used.

TABLE 3

Oil charge to plant, gallons per hour....	100	100
Trichlorethylene-oil dilution	45:55	60:40
Water, gallons per minute.....	20	40
Exhaust steam, pounds per hour.....	270	390
Live steam, pounds per hour.....	60	90
Power, kilowatts	8	19
Solvent, loss, per cent by volume on oil charge	0.6	0.9
Approximate plant cost, dollars per 100 gallons per hour .....$30,000-$35,000		$55,000-$60,000

The data given in Table 3 should be ample to enable anyone interested in the process to calculate the operating costs by his own particular method, and from figures so obtained it may then be readily determined whether the process would appear to have any advantages over the dewaxing methods which might be currently used. On the basis of the data given in Table 3 the operating costs per 100 gallons for the two plants should work out to $1.40 to $1.50 per hundred for the low-wax-content stock, and $2.10 to $2.20 per hundred for the high-wax-content oil.

Filtering Wax from Petroleum Oils *With* Filter-Aid

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The Texas Company

TULSA, OKLAHOMA MAY 17-19, 1933

FILTER-aid are finely divided solids, highly porous in nature, that assist in the separation of liquids from suspended matter by filtration. Filter-aid acts as a framework, a reinforcement, whereby the fine plastic, compressible solid to be removed is maintained in a more rigid, pervious state on the filter cloth for subsequent washing and drying. Diatomaceous earths have been used extensively for this purpose, and during the past several years considerable attention has been given to use of these materials in petroleum dewaxing.

In commercial operations at the filter-aid dewaxing plants of The Texas Company and the Tide Water Oil Company, materials such as Johns-Manville "Hyflo Super Cel" and Dicalite "White Speed Flow" have been used as filter-aids. These materials are almost pure silica, and lend themselves easily to reconditioning for reuse indefinitely in the filter system at little cost.

To illustrate the effect of filter-aid addition: a narrow cut "overhead" lubricating distillate from Mid-Continent crude, of 49 Saybolt viscosity at 210° F. and 100° F. initial pour test, could not be handled by the conventional methods of dewaxing. The distillate was diluted with 65 per cent plant naphtha of about 58° A.P.I. gravity in order to reduce the viscosity, then chilled to —23° F. and filtered through heavy filter canvas. The filtered solution was cloudy with wax and on reduction showed a pour test of 45° F. Wax remaining on the filter canvas was sloppy and high in oil content. To another portion of the chilled, wax bearing solution an amount of filter-aid equivalent to one fourth-pound per gallon of solution, was mixed in and this mixture filtered on a similar filter cloth. The filtered solution, in this case, was perfectly brilliant and on reduction showed a pour test of 20° F. Furthermore, the wax filter-aid cake was firm and in such a form that it could be easily washed with additional naphtha to remove surplus oil.

By using sufficient filter-aid with the precipitated wax in a sufficiently low viscosity solution of the oil, any type of petroleum wax can be removed from any grade of oil.

OILS PROCESSED

Examples of some of the various oils that have been processed are given in Table I. These grades have ranged from low viscosity paraffine distillates to high viscosity residual cylinder stocks; both wide and narrow cuts of distillates and residua have been handled; and waxes ranging from very soft, low melting points waxes in partially pressed distillates or neutrals to the more rigid, highly crystalline waxes contained in some types of oils have been removed. Resultant pour tests of the oils can be raised or lowered by altering the filtering temperature and the dewaxed oil remains cloud free in almost all cases below the pour point.

NAPHTHA USED AS DILUENT

Commercial operation of filter-aid dewaxing has been restricted to use of petroleum naphthas as the oil solvent or diluent, and examples given in Table I are for oils that have been diluted with naphtha. This naphtha generally runs from 58° to 59° A.P.I. gravity, with a boiling range of about 150° to 380°F. and a Saybolt thermo-viscosity at 60° F. of about 130 to 150. As indicated by the difference between filtering temperature and resultant solid point of the dewaxed oil, which we call "dewaxing differential," some wax, as well as all of the oil, is soluble in naphtha at low temperatures. This solubility of wax and the relatively high viscosity of naphtha are its chief disadvantages. Its advantages are, of course, its common availability, ease of handling and low cost.

SPECIAL SOLVENTS USED AS DILUENTS

However, with the increasing commercial production of various other suitable organic solvents of lower viscosity, these may be used to advantage in combination with filter-aid to result in increased rates of flow or capacity, and, in some cases, lower pour tests due to decreased solubility of waxes in the diluent. Table II shows temperature-viscosity curves (viscosity by Saybolt thermo-viscosimeter) for a few of these solvents in relation to the grade of naphtha that has been used in commercial operating filter-aid dewaxing plants. Table III gives a comparison of experimental results obtained by using naphtha with filter-aid, and acetone-benzol mixture with and without filter-aid and shows the effect of adding filter-aid in acetone-benzol solution on rates of flow, solid points, and dewaxed oil yields.

In the case of the vacuum lubricating distillate the effect of the lowered solution viscosity on rate of flow for the same filtering temperature is clearly shown, even though larger amounts of wax were removed, due

TABLE I

Grade of Oil	Pfle. Dist.	Pressed Dist.	Long Dist.	Lube Dist.	Long Dist. Stock	Long Residuum	Cylinder Stk.	Overhead Cyl. Oil
Crude Source	Ranger	Pennsylvania	Oklahoma	Coastal	Mid-Cont.	Pennsylvania	North Texas	Oklahoma
Distillation Method	Vac. Tube Still		Vacuum	Vac. Tube Still	Vacuum Still	Vac. Reduced	Steam & Fire	Vac. Frac. Tower
Previous Treatment	None	Cold Pressed	None	SO_2 Treated		Percolated to Color	Acid & Clay	Centrifuged
Gravity, °A.P.I.	29.9°	34.7°	29.5°	25.9°	23.8°	28.0°	23.7°	20.2°
Flash, °F	355°	305°	375°	430°	490°	485°	555°	535°
Fire, °F	395°	335°	420°	485°	575°	555°	640°	600°
Vis. (Say) @ 100°F	93	78	244	326	.....	.....	.....	.....
Vis. (Say) @ 210°F	39	.....	49	51	76	97	160	171
Color, # N.P.A.	.....	#1	#3½	#3½	Dark	#6	Drk. Green	Drk. Green
Initial Pour Test	65°F.	25°F.	65°F.	60°F.	100°F.	95°F.	85°F.	10°F.
Resultant Pour Test	—10°F.	— 5°F.	10°F.	15°F.	20°F.	15°F.	30°F.	5°F.[2]
Filtering Temp. °F	—35°F.	—28°F.	—10°F.	+3°F.	—10°F.	—27°F.	+13°F.	—16°F.
% Naphtha in Solution	45%	40%	55%	60%	65%	72%	67%	72%
#Filter-Aid (dry) /gal. solution	¼#	½#	½#	½#	1#	¾#	⅜#	⅙#
[1]Amount Wax Removed	11.4%	2.2%	4.6%	2.0%	9.1%	15.5%	8.0%	1.5%
Melting Point of Wax	112°F.	94°F.	130°F.	130°F.	140°F.	125°F.	139°F.	137°F.

(1) As determined by wax analysis of discharged cake, expressed as percent by weight original oil charged.
(2) Centrifuged solution filtered to remove floating wax which caused high cloud, then treated for color. Pour Test given on treated oil, number 4½ color, no cloud at —14°F.

to the decreased solubility of wax in the diluent. The effect on dewaxed oil yields when adding relatively small amounts of filter-aid is also shown. The dewaxed oil yield increased as the amount of filter-aid increased, and it has been determined that this increase in yield will continue to a definite critical peak, where the oil soakage in the surplus filter-aid material will cause a decrease in yield. This has also been found to be true when the filtering temperature has been adjusted to result in the same dewaxed oil solid point, or, in other words, to remove the same amount of wax as from the naphtha solution.

The long distillate stock example, which was a wide fraction from vacuum distillation containing all lubri-

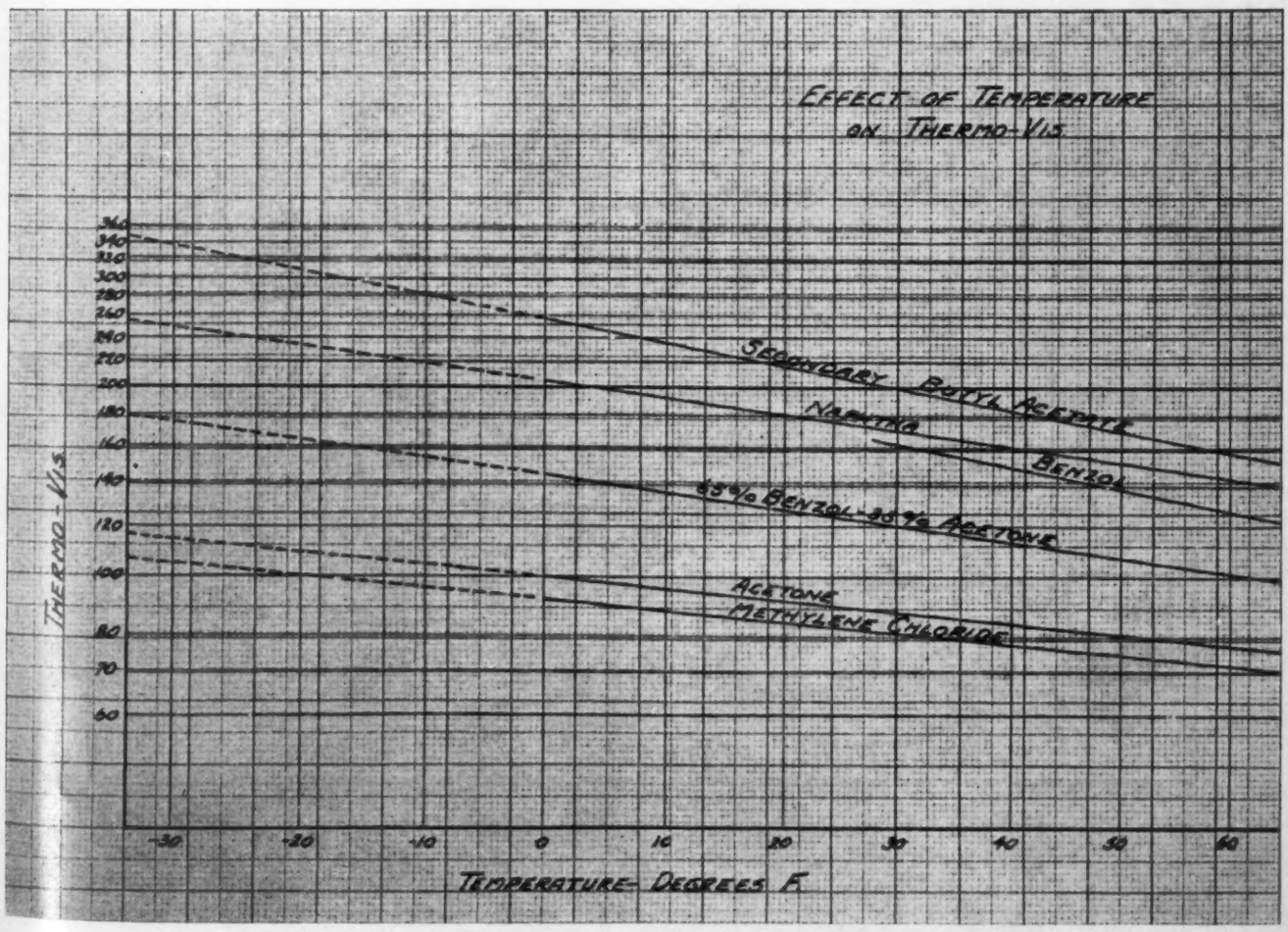


TABLE 2

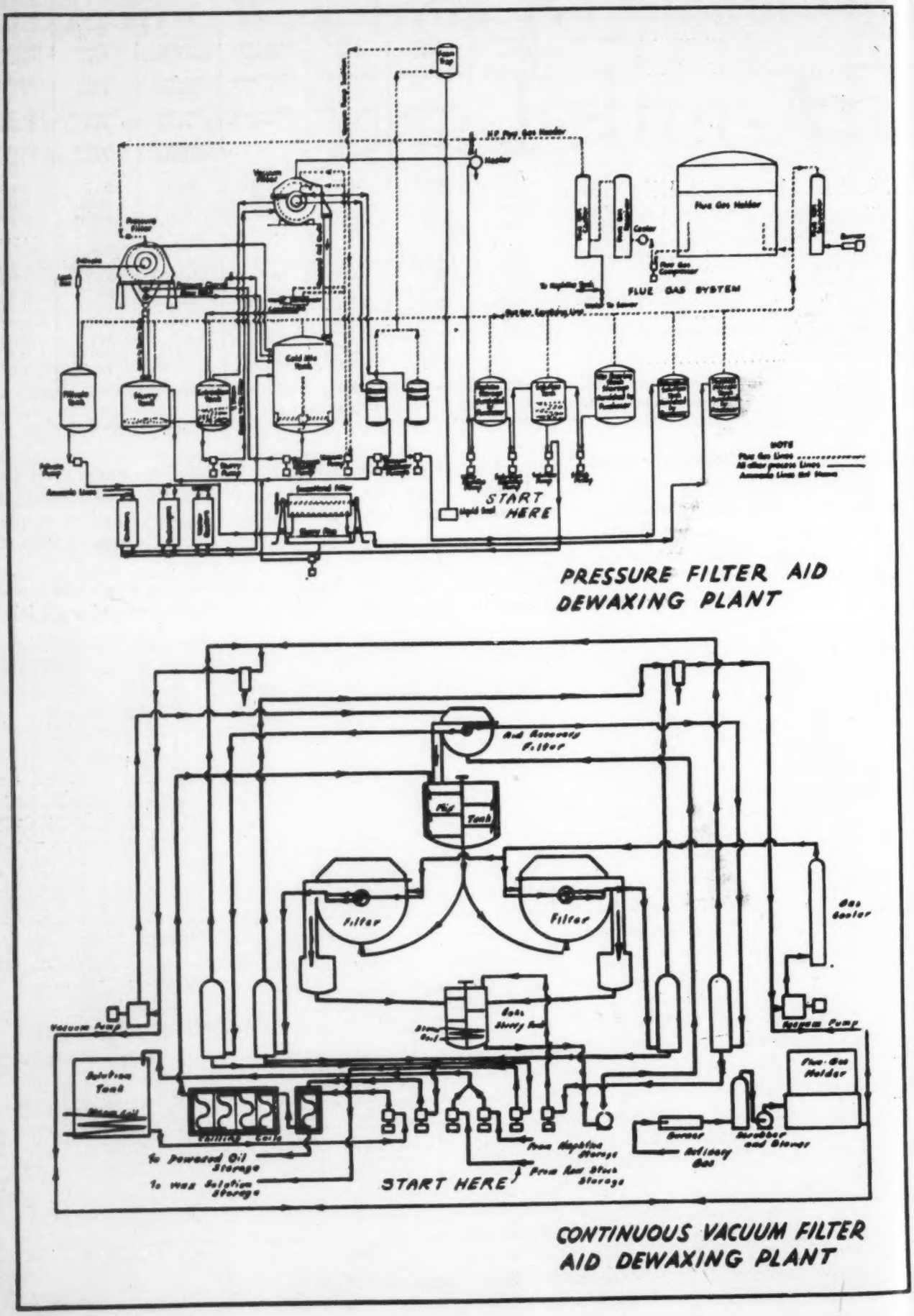

FLUE GAS SYSTEM
START HERE
PRESSURE FILTER AID
DEWAXING PLANT
Filter
Filter
START HERE
CONTINUOUS VACUUM FILTER
AID DEWAXING PLANT

FIGURE 1

cating oils down to and including bright stock, shows the effect on rate of flow when the same filter-aid concentration per barrel of wax bearing stock is used and the solutions have been adjusted to about the same thermo-viscosity.

All the yields shown can be increased by displacement washing with additional cold solvent, but the washing efficiency on the cakes containing filter-aid is generally much higher due to the fact that the cake is "opened up" or made more porous, thus allowing the absorbed oil to be easily washed out, with a minimum of additional solvent and refrigeration.

TABLE III

Grade of Oil	Vacuum Lubricating Distillate				Long Distillate Stock		
Vis. @ 210°F			51			76	
Initial Pour Test. °F			60°			100°	
Diluent Used	Naphtha		35% Acetone 65% Benzol		Naphtha	35% Acetone 65% Benzol	
% Diluent in Solution	55%		55%		65%	54.4%	
Solution Viscosity (See note [3])	570		400		590	556	
Solution Cloud Point, °F	40°		50°		72	88°	
#Filter-Aid (dry) /bbl. sol.	30	None	4	8	40	None	52[6]
Filtering Temp., °F	—18°	—18°	—20°	—20°	—10°	—11°	—10°
Dewaxed Oil Rate of Flow (See note [4])	0.6	1.6	1.6	2.4	0.9	0.7	1.8
Dewaxed Oil Solid Point	+ 4°	—10°	—12°	—14°	+16°	0°	— 2°
Yield Dewaxed Oil (See note [5])	88.2%	72.2%	82.7%	86.5%	73.3%	51.2%	60.0%

([3]) Saybolt thermo-viscosity @ 60°F.
([4]) Gallons dewaxed oil/sq. ft. filter area/hr.
([5]) By weight, original stock, no washing on filter.
([6]) Equivalen tto 40# dry aid/bbl. sol. containing 65% diluent.

The importance of solution viscosity as it affects rates of flow is again shown in the case where the viscosity of a regular naphtha was reduced from 153 to 109 thermo-viscosity at 60° F. by introducing lower boiling petroleum hydrocarbons. When this lower viscosity naphtha was used in the same proportion as regular naphtha as the oil diluent, the consequent reduction in solution viscosity caused a 30 per cent increase in capacity over the regular naphtha solution under comparable dewaxing conditions.

Flow sheets are given here with a general description of operation of pressure type and vacuum type filter plants on dewaxing with filter-aid. (Figure 1.)

PLANT EQUIPMENT

Plant equipment may be classified in the following groups:

1. Refrigeration and chilling equipment—a necessary adjunct to any dewaxing plant.
2. Filter-aid mixing tank — for mixing filter-aid in chilled solution.
3. Filters for dewaxing oils, with usual accessory equipment common to the average modern filter plant.
4. Wax filter-aid cake handling equipment, consisting of receiving tank, melting tank and pumps.
5. Filter-aid recovery filter.
6. Inert gas system—for recirculation of vapors, with small "make up" generator.
7. Stripping stills, common to any dewaxing plant.

Both types of plants are arranged for continuous flow of materials, the pressure filter plant depending on alternate operation of the filters to maintain a constant flow through the plant and on pressure feed pumps or tanks to charge the filters. Vacuum filters, on the other hand, are continuous and automatic in their operation and feed to the filter is obtained by gravity flow from the mixing tank.

METHOD OF OPERATION

In both plants the wax bearing oil is first mixed with naphtha; heated, if necessary, to dissolve all wax; and then the wax crystallized by chilling, first through oil to oil exchangers, and then by a refrigerating medium, such as brine or ammonia. Direct expansion is preferable when very low temperatures are required.

No attempt has been made to slowly chill or control the precipitation of the wax. In most cases, when proper amounts of filter-aid and diluent are used, the detrimental effect of "shock" chilling is not sufficient to warrant the additional amount of chilling surface or control necessary for slow chilling.

When the wax bearing solution has been chilled and the desired amount of wax made insoluble, it flows to the mixing tank into which the filter-aid falls direct from the recovery system. In the present systems reconditioned aid coming from the recovery filter is warm and the wax bearing solution must be chilled to a lower temperature than the desired filtering temperature so as to compensate for the consequent rise in temperature. The magnitude of this use will, of course, vary with the filter-aid concentration and naphtha content of the filter-aid, but the usual increase is from 7 to 12 degrees.

Only a short time is required for intimate mixing of filter-aid with the chilled wax bearing solution, this being accomplished by paddles in an insulated or jacketed mixing tank.

The cold slurry of wax and filter-aid flows directly from this tank to the filter in the case of vacuum filters, or to pumps in case of pressure filters. The filter station installation and operation is no different from the usual practice in other industries, though it is necessary to insulate the filters or enclose them in a cold room to prevent radiation losses.

Filter-cloth, woven of cotton, on the filter elements retains the wax filter-aid particles and the dewaxed solution flows through, passing out of the plant by way of the exchangers.

The wax filter-aid cake, formed on the filter cloth, is washed with additional cold solvent when necessary to improve yields, dried with cold inert gas and discharged to a mechanically agitated slurry tank.

Weak wax solution coming from a wash receiver at the filter-aid recovery filter is added to the wax filter-aid cake in slurry tank so as to form a pumpable

slurry. This slurry is then heated to about 150° F. to dissolve all wax and is pumped up to aid recovery filter located above mixing tank and cold filter.

FILTER-AID RECOVERY

The filter used for recovering filter-aid is in all cases a vacuum continuous filter, operating automatically and relatively small in size compared to the cold filter area. For example, at the Tide Water plant a recovery filter one tenth the area of the dewaxing filter supplies an adequate amount of aid. On this filter the following sequence of operations is obtained continuously at vacuum of about 15 inches hg.

First, filter-aid is separated from the hot wax solution and a filter-aid cake formed; second, any absorbed water is flashed off under vacuum; third, the filter-aid cake is washed free of wax with fresh hot solvent; fourth, the cake is dried with inert gas; and fifth, the filter-aid cake is charged back to the cold mix tank.

The separated solution containing wax, as well as the weak wax solution from washing the cake on the filter, is withdrawn continuously from receiver by receiver pumps, and discharged to storage. In this way the filter-aid is reconditioned for re-use and re-cycled indefinitely in the filter system.

On recovering filter-aids like "Hyflo Super Cel" or "White Speed Flow," the recovered filter-aid cake has the following analysis:

Dry aid	63.0 per cent
Naphtha	36.0 per cent
Oil and wax	0.8 per cent
Water	0.2 per cent

When recovered in the above manner the filter-aid on re-use gives a rate of flow about 50 per cent to 60 per cent of that of new aid. It remains at this efficiency on continued use and reconditioning indefinitely; so with a system properly closed, very little "make-up" aid need be added, once the system is charged.

Both the dewaxed oil solution and the wax solution are stripped of naphtha and the naphtha returned for re-use.

Inert gas is circulated in a closed system, preventing solvent loss and fire hazard. It is best to use a gas holder to iron out any fluctuations in gas flow, and with the use of a gas holder only a very small inert gas generator is needed.

PLANT COSTS

A pressure filter plant, as above described, operating on an average wax bearing oil, can be erected complete, exclusive of building to house equipment, for a cost ranging from approximately $500 per barrel of stock charged per day for a 1000 barrel plant to a cost of $900 per barrel for a 300 barrel plant.

A vacuum filter plant, as above described, operating on an average wax bearing stock, can be erected complete, exclusive of building to house equipment, for a cost ranging from approximately $100 to $200 less per barrel of stock charged per day than for a pressure filter plant of the same size.

Table IV gives an approximate break-down of these plant costs expressed in percentage of the total erected cost for both a pressure and a vacuum filter plant.

TABLE IV

	Pressure	Vacuum
Chilling equipment, exchangers, etc.	13.2%	18.2%
Refrigeration equipment, complete	9.5	12.1
Filters for dewaxing and accessories	21.9	34.0
Tankage, solution, mix, slurry, etc.	6.9	6.9
Pumps, with motors and controls	7.3	1.2
Aid recovery system, complete	5.4	4.7
Piping, wiring, conveyors, etc.	15.6	8.9
Insulation, hot and cold	7.8	10.1
Inert gas system, complete with holder	12.4	3.9

These approximate figures clearly show why a vacuum continuous filter plant can be erected for a lower cost than a pressure filter plant, as considerably fewer pumps; less piping, insulation, and tankage, and fewer conveyors are required for the plant; and no high pressure compressor is needed for the inert gas system.

Average costs of dewaxing on a vacuum continuous plant run from 1.4 to 2.7 cents per gallon of dewaxed oil, including refrigeration and filter-aid recovery costs, but not including stripping cost of dewaxed oil and wax solution or fixed plant costs.

A question no doubt comes to mind at this time as to what determines the selection between a pressure filter plant and a vacuum filter plant. In the light of present development and past experience this question is rather difficult to answer at this moment. The Texas Company's filter-aid dewaxing plant at Port Arthur is a pressure filter plant and the Tide Water Oil Company's filter-aid plant at Bayonne is a vacuum continuous plant; each have handled a variety of stocks and represent steps in the evolution of the present conception of plant design, rather than typical examples of a pressure and vacuum continuous plant.

Greater filtering pressure differential, up to 150 pounds per square inch on the present filters, is obtained in a pressure filter plant, and this may be of advantage in gaining capacity when relatively high solution viscosities are used. Smaller amounts of filter-aid can be used on low wax content oils with consequent higher yields of dewaxed oils; or, in other words, the cake thickness, which is of such great importance in successful operation of filters, can be controlled more by prolonging filtration time under increasing pressure rather than by adding surplus amounts of aid to give cake forming solids. A certain amount of compressing or squeezing action is also obtained under pressure and this contributes to higher yields. If a very low boiling point solvent is used, it is, of course, necessary to use super-atmospheric pressures.

On the other hand, as now demonstrated at the Tide

Water plant, a vacuum filter plant is continuous and practically automatic in operation, a very low volume of liquid is carried in the system, the plant is compact and requires only about a third to half of the labor that a pressure filter plant requires.

THE TEXAS COMPANY PLANT

The Texas Company plant was built in 1928, and consisted of four Kelly type pressure filters, built for 250 pounds per square inch operation pressure and giving a total filter area of 1760 square feet; a brine refrigerating system; the necessary pumps and chillers as conceived at that time; and a separate filter-aid recovery system using a disc type vacuum filter of two 50 square foot discs. All of this equipment is obsolete today, and results and cost are of little value in a study of filter-aid dewaxing. A totally enclosed rotating disc pressure filter, of 400 square feet of area, was later installed to demonstrate the feasibility of closed filter operation.

Stocks processed in this plant have been chiefly acid treated and clay contacted residuum bright stocks and cylinder stocks and overhead distillate cylinder stocks from North Texas and Oklahoma crudes, with viscosities ranging from 90 to 160 at 210° F., 90° to 100° F. pour test, and containing relatively high per cent waxes.

Bright stocks and overhead distillate stocks were run for 20 to 25° F. pour tests, and "E" cylinder stocks for 30 to 35°F. pour, with filtering temperatures ranging from —15°F. on the former to +5°F. on the latter. Dewaxed oil yields ran as an average from 80 per cent to 85 per cent on the basis of the original stock charged.

An average rate of flow of about 0.45 gallons of dewaxed oil per square foot of filter area per hour total time has been obtained at this plant on the stocks mentioned.

Filtering temperatures, and therefore, pour tests, are limited due to the brine refrigerating system, and plant capacity is limited by the inefficient filter-aid recovery system and type of filter used. However, yields of dewaxed oil for the same stock and pour tests have been equal or better than that obtained on centrifuge operation.

The Texas Company plant has served to demonstrate the possibilities of filter-aid dewaxing as applied to any type of wax contained in lubricating oil fractions, whether this wax be crystalline or amorphous, and has demonstrated its applicability to both residual and distillate oils. It has demonstrated the fact that the product does not show a wax cloud down to its solid point and often does not show a cloud considerably below its solid point. It has also proven, running in parallel with the centrifuge plant, that the filter-aid process in dewaxing distillate oils gives much more efficient separation than does the centrifuge and the separation is easily controlled.

TIDE WATER OIL COMPANY PLANT

Many of the disadvantages of The Texas Company plant were corrected in the Tide Water Oil Company plant, built in 1929. The major improvement being in the filter-aid recovery system. Where the Texas plant filter-aid recovery system consisted of many pumps, tanks, dehydrating stills, wash tank, conveyors, etc., occupying a separate four-story building and requiring one or two men to operate; the Tide Water filter-aid recovery system consists of one relatively small drum type vacuum continuous filter, one small naphtha heater to supply wash for the filter, and one pump; the filter occupying a space about 10 feet wide by 14 feet long and is entirely automatic in its operation. Flow of materials and operation of this filter has been given under the general plant description.

The Tide Water plant is equipped for direct ammonia expansion and uses, besides oil to oil exchangers, six Gray chilling towers. The filter used is a vertical disc type vacuum continuous filter of 1000 square feet area, with the necessary vacuum pumps, receivers, etc. Control devices have been used extensively in the plant to control levels in tanks and filters, and control temperatures.

A variety of wax bearing oils have been processed in the Tide Water plant, among these being partially dewaxed Pennsylvania and Mid-Continent neutrals ranging from 200 to 400 viscosity at 100°F., with an initial pour test of 30° to 35°F. and a resultant pour test of 0° to —5°F. when filter-aid dewaxed. Other stocks processed are Pennsylvania long residuum and bright stock, coastal lubricating distillates and other wax bearing distillates of various viscosities.

Filtering temperatures range from —35°F. to 0°F. depending on the pour test required, and pour tests have run from —10°F. to +35°F. Dewaxed oil yield of about 85 per cent to 87 per cent is obtained as a rule on the average charging stock without washing on the filter.

An average rate of flow of about 1.0 gallon of dewaxed oil per square foot of filtering area per hour continuously is obtained on the lower viscosity oils and ranges down to about 0.3 gallon per square foot per hour on the more viscous stocks. Vacuum on the dewaxing filter is maintained at about 24 to 25 inches Hg.

DEWAXING COST ANALYSIS

An analysis of the Tide Water dewaxing plant operating cost shows approximately the following, expressed in per cent of total dewaxing cost per gallon of dewaxed oil, not including stripping of solution or indirect plant expense:

Labor	25.00%
Repair	16.00
Sundry Replacements	0.02
Filter-aid Make Up	0.01
Naphtha	8.6
Loss*	8.60
Ammonia Replacement	0.01
Steam	15.30
Electricity	28.60
Fuel (Gas) and Water	0.01
Indirect Plant Expense	6.45

*Includes stripping losses at stills.

Filter cloth replacement, included under "Sundry Replacements" only amount to $8.00 to $10.00 per month.

"Filter-Aid Make-Up" is a very small item, and can be eliminated entirely by installing a small clarifying filter to collect the aid that passes through due to faulty cloth.

Naphtha loss shown includes losses at distillation plant, the total volumetric loss being about 0.7 per cent. However, Tide Water does not use a gas holder on the inert gas recirculating system, so some excess vapors escape from the system.

Considerable research and engineering development work has been done during the past three years toward simplification of plant design and elimination of some of the difficulties remaining.

A semi-commercial pilot unit, consisting of a drum type vacuum filter, was put in operation at one of the commercially operating plants to assist in this development work. This filter ran in parallel on the same charging stocks as the large plant filter.

This work indicated that considerable filter-cloth plugging could be eliminated by maintaining nearly a constant temperature throughout the filtering cycle of operation by using cold inert gas for drying the filter cake. This constant temperature does not allow the wax in the formed filter cake to partially melt and redissolve as happens when relatively warm inert gas is used, and consequently no melted wax can reach the filter fabric and plug it by re-crystallizing in it when the filter fabric is again re-immersed in the cold filter slurry.

Furthermore, much better discharge of the filter cake is obtained on a drum type vacuum filter. The discharge efficiency of the drum type filter was found to be about 100 per cent, while a vertical disc type filter only runs about 60 per cent efficiency.

Due to these two improvements; namely, use of cold inert gas for drying cake and improving discharge of cake by use of drum type filter; the pilot unit ran consistently at least double the rate of flow and a pour test 10° to 15°F. lower than that obtained on the plant filter.

CONCLUSIONS

We feel reasonably certain as a result of this work that a drum type vacuum filter used with cold inert gas, will materially increase capacity and give lower pour test. Due to the fact that a highly efficient displacement wash can be used on a drum type filter, a material increase in yields can be obtained. We have found, in actual practice on pressure filters and experimentally on vacuum filters used on dewaxing, that, as a rule, the oil content of the cake can be reduced by displacement washing to a point where an approximate ratio of 0.6 pound to 0.4 pound oil per one pound wax, as determined from cake analysis, is left in the cake. Additional solvent required for this displacement is an amount equal to about 30 to 35 per cent of the volume of original wax bearing solution charged. Yields can be increased even more by using an increased percentage of additional solvent. This is a matter of economic balance.

A displacement wash similar to what is proposed for the drum type filter is used on the aid recovery filter.

The economic success of any given investment in a dewaxing plant, of course, depends on quantity throughput, provided desired qualitative results are obtained.

In a filter-aid plant this quantity throughput is controlled largely by the following factors:

1. Viscosity of solution.
2. Character of crystallized wax.
3. Condition of filter cloth.
4. Mechanical operation of filter.
5. Ratio of filter-aid to wax recovered.
6. Character of filter-aid.

The viscosity of regular naphtha is recognized as a limiting factor; but, if economical, this can be reduced by adding lighter boiling point fractions to the naphtha or use of a special solvent to increase capacity.

The character of the crystallized wax effects rates of flow to some extent, but may be controlled largely by slow chilling if necessary, though additional filter-aid and lower solution viscosity tends to overcome the effect of difference in character of waxes.

By maintaining a constant temperature throughout the filter cycle by means of cold inert gas and maintaining discharge efficiency, filter cloths of proper weave can be maintained in highly porous condition.

Use of a drum type filter or of totally closed pressure filters will improve discharge efficiency of cake and result in an easier manipulated plant, probably reducing labor costs.

By the use of the filter-aid recovery system, as operated at the Tide Water plant, the ratio of filter-aid to wax and character of the recovered filter-aid can be easily controlled.

Use of the entirely closed inert gas system eliminates solvent losses at the dewaxing plant.

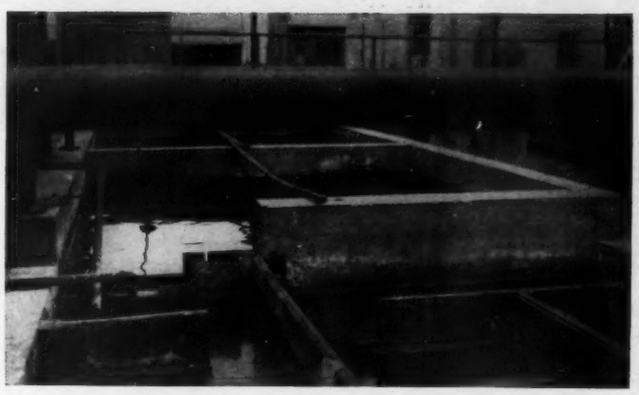
We believe that by the improvements mentioned above rates of flow or plant capacities can be doubled over those now being obtained and the average costs of dewaxing consequently materially reduced.

With the proper proportion of naphtha, up to 70 per cent on the higher viscosity oils, filtering temperatures as low as —35°F. are feasible, with resultant pour tests running as a rule about 20° to 30°F. above the filtering temperature, depending on the solubility or melting point of the wax removed.

The filter-aid method can also be used to recover low pour test oil from petrolatums, decloud partially dewaxed oils and asphalt base oils, as well as remove any type of wax from any grade of wax bearing oil.

Treating Refinery Waste Water To Prevent Contamination

GARBER Refinery, Incorporated, Garber, Oklahoma, formerly disposed of refinery waste water through the sewage system of the city of Garber. Late 1931, the city authorities decided that the acids and caustic residues contained in the refinery waste might create difficulties in their sewage system, so they denied further right of the refinery to use this system for waste water disposal. Having no other outlet for this waste water, the management of the refinery decided to construct a system by which the waste water could be treated and reused in cooling and condensing, with no drainage of any water from the plant.



Chemical mixing box, and details of pit construction for waste water recovery plant.

After analysis it was found that the water could be satisfactorily and economically treated with hydrated lime and sodium aluminate. In order to accomplish this and recondition the water so that it could be used in the cooling units of the various condensing systems, a large pit was excavated. When finished, the system consisted of two pits, one, the principal treating unit, approximately 25 feet in width, 50 feet in length and six feet in depth. The other, a smaller unit at the outlet end in which the treated water is accumulated and from which it is pumped to the condenser boxes. Both pits were lined with concrete. The larger pit was divided into three sections by running dividing walls lengthwise of the unit so that the water in traveling through must pass the length of the pit three times before being emptied to the receiving pit.

The first section in the large pit was subdivided into five sections, the first four being skimming units in which the oil is removed. The water to be treated empties into the first of the skimming units at the surface of the water, and from it and the others it is transferred by syphoning to the succeeding tank. In the center of each of the four subdivisions, a standpipe was provided which permits the oil carried over to be drained as it is skimmed from the surface. These skimmer lines lead to a common pit where the oil is picked up and pumped to "slops" and rerun through the plant or disposed of otherwise.

The fifth subdivision of the first section contains the turbulent section in which the chemicals are mixed with water and the first part of the treating operation is accomplished. This section is provided with wood baffles so constructed that the water must travel back and forth before being admitted to the second section. Chemicals are prepared in a small house beside this section and admitted to the water to be treated. First the hydrated lime is added to the water at the first baffle, and immediately afterwards the sodium aluminate is led in. Reaction takes place primarily in this baffled section and continues as the water passes through the other section of the pit.

Mixed with the lime and sodium aluminate, the water travels through the second and third sections where sedimentation and clarification takes place. A perforated line in the bottom of these sections is connected to the suction of a steam pump and removes treating sludge to a disposal pit in the refinery yard. This is the only part of the waste water accumulation and treating that must be disposed of otherwise than being used again.

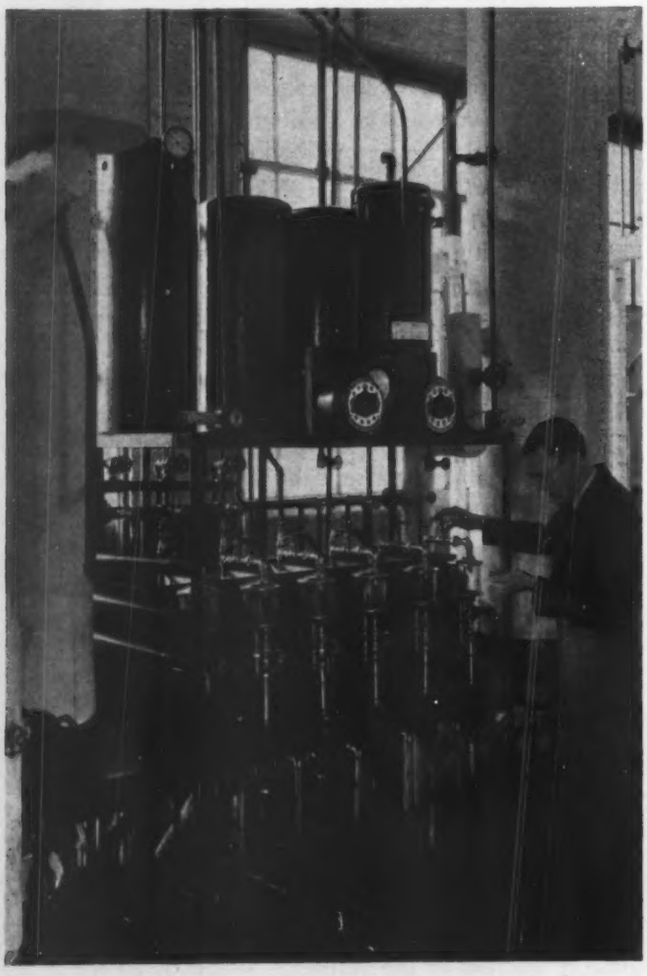
Make up water from the refinery source is added to this waste water and treated in the same manner, being mixed with the waste at the point of entry to the treating unit. Costs are low, as only about 100 pounds of hydrated lime and 10 pounds of sodium aluminate are required to treat water each 24 hours. The system was installed by International Filter Company, Chicago (Ref. & N. G. M., Vol. 11, Oct., 1932, Page 523).

Through this inexpensive system, not only has the sewage disposal system of the plant been protected, but water that otherwise was thrown away is used over again. It is used only in the condensing and cooling system of the refinery. Water used for other purposes is treated in a separate system.

Coubrough Process *for Maximum Recovery of Lubricants*

DEVELOPMENT in the refining art has progressed to the point where lubricating oils of quality satisfactory to present day needs can be produced from a wide variety of crude oils. The utilization of vacuum in distillation has proven a valuable step in providing means of recovering lubricatings oil from such oils as mixed base and napthenic crudes with the result that its use in the industry is now quite general. However, the possibility of increasing the yields of heavy lubricants and of lowering processing costs offers a wide field for investigation.

Usual practice in distilling reduced crudes to secure lubricating stocks consists in subjecting such charging stocks to pipe still heating with subsequent flashing and rectification of distillates in a vacuum fractionating column. In processing a mixed base or naphthenic base crude the distillates range from gas oil to overhead cylinder stock, the residue being a flux. In heating such a stock in a pipe still, the heat is added to the oil under a pressure much greater than that which can be maintained in the vaporizing zone, so that practically all of the heat required vaporization must be added as sensible heat of the liquid. If complete recovery of the heavier lubricating oils as distillates and asphalt as residue is attempted, the temperature required is likely to be so high that cracking is virtually inevitable and, as is well known, the effects of such cracking on both distillate and residue is undesirable. However, most of the lubricants may be distilled without reaching temperatures conducive to serious cracking, but only at the expense of decreased yields of valuable heavier lubricating oil and an increased yield of the less valuable flux. When running a crude oil of low asphaltic content, such as Ranger crude, operating conditions necessary for the complete recovery of the heavier lubricating oils by distillation become unusually severe. As a result, refiners consider it better practice to produce residual lubricating oil stocks from such crudes. These residues are then either acid treated or the contacting operation employed for the removal of the asphalt, which practice indicates the loss of asphalt as a product concurrent with the usual expense of chemical treatment.



Control instruments and products gauges on operating floor

Various means for effecting more complete recovery of the valuable heavier lubricating stock from flux residues have been tried. One method involves the flashing of the hot residue from the preceding distilling column under high vacuum. Generally, there is insufficient sensible heat in the flux to accomplish much additional vaporization. If more heat is necessary its addition introduces the danger of cracking. Another method involves stripping the hot flux under a vacuum with superheated steam. Because of the increased volume of steam under vacuum, efficient contacting is hard to obtain and en-

General view of fractionating columns, control instruments, and products gauges, with experimental units in Lummus Company laboratory.

trainment increases the difficulty of producing a clean distillate. The possible formation of troublesome emulsions may also be encountered.

The factors influencing vacuum distillation in a fractionating tower are such that one desirable result can only be obtained at the expense of another. When vacuum distilling a reduced crude, maximum recovery of distillates is secured by maintaining a high vacuum in the vaporizing zone. Well fractionated distillates, however, can only be obtained by the use of a modern efficient fractionating column and because of the necessary design of such columns a relatively poor vacuum is secured at the point where a high vacuum is most desirable, namely, the vaporizing chamber. The design of equipment now available is based on a compromise between these two factors.

The Coubrough Process developed in the laboratories of The Lummus Company, is the result of a program of experimental work which has been in progress for some time. In principle the new process calls for flash vaporization of a blend of flux or fuel oil residuum with non-vaporizable asphaltic material and a light distillate or "carrier." The blend is controlled to give a mixture of such proportions that the desired vaporization is readily accomplished without danger of exceeding cracking temperature and without the necessity of employing high vacuum. A typical residuum used would contain essentially nothing but cylinder stocks and asphalt. Operating methods presently in use readily produce a residuum of such character without sacrificing fractionation of the lighter lubricating oil distillates. To such a residuum is added asphaltic material which for all practical purposes is non-vaporizable. The necessity for this addition is naturally determined by the characteristics of the crude oil being processed, since a number of crudes contain sufficient asphalt to make

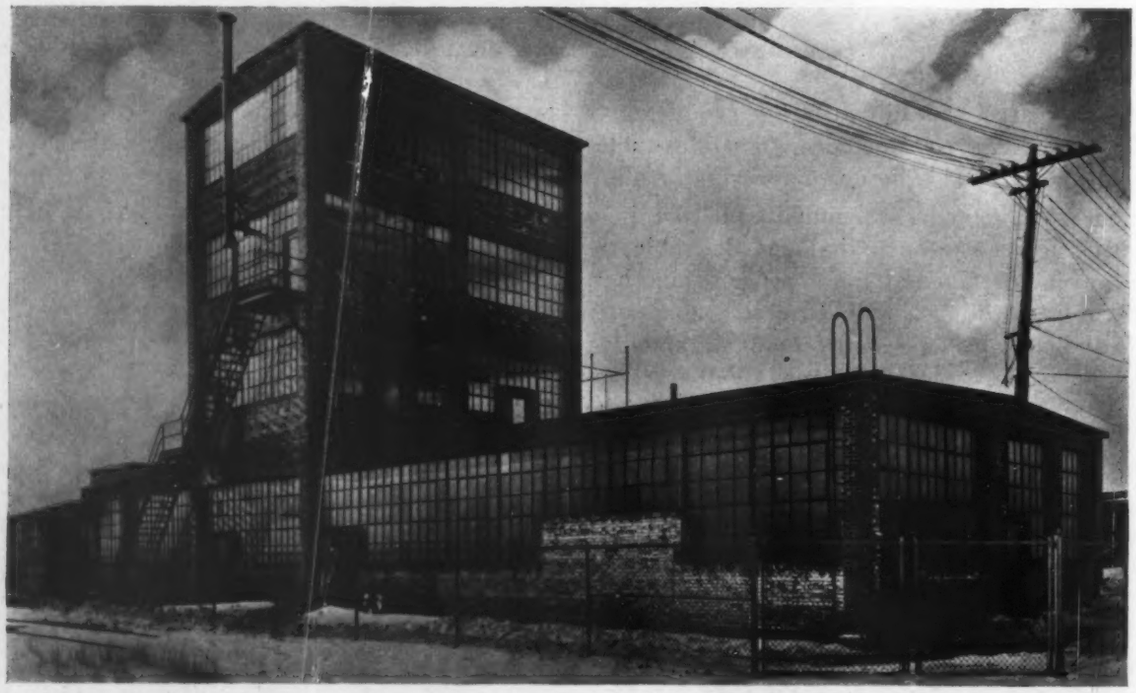
this step unnecessary. When processing residues from crudes of low asphalt content, this additional asphaltic material has a definite function in providing the proper blend.

The "carrier", which is any available distillate having a boiling range from heavy naphtha to light gas oil is injected into the stream through a mixing device and the three components thoroughly admixed to form a homogeneous blend. The finished blend is passed into a pipe still for heating and introduced into a specially designed vacuum column where the heavy lubricating oil fraction and the "carrier" are flashed off as vapor, leaving the asphalt as the unvaporized residue. Inasmuch as there is a large gap between boiling points of the "carrier" and the heavy lubricating oils, the separation of the two from the vapor mixture is accomplished quite readily. So flexible is the adjustment of the blend and the heating that the method can be applied to any residuum, no matter what proportions of heavy lubricating oil and asphalt it may contain originally.

The creation of the proper blend provides a charging stock of relatively low viscosity, simplifying pumping problems and permitting efficient heat transfer in a pipe still without danger of overheating. The intimate mixture of all of the materials of the blend means that the so called "lifting effect" of the "carrier" in vaporizing the heavy oils occurs throughout the whole of the body of the heated mixture and consequently is very effective in vaporizing these oils. The lower boiling point of the heavy oils in the presence of the "carrier" enables the distillation to be effected at relatively lower temperatures than other processes. The addition of asphaltic material to the blend creates a heat reservoir which supplies heat required for vaporization without going to high pipe still temperatures. These are the points which the owners of the process stress as being worthy of consideration and study.

The Coubrough Process is designed to secure an increased yield of heavy lubricating oils simultaneously with the continuous production of high quality asphalts, and the operation of the process is both simple and flexible. The light distillate used as a "carrier" is available in any refinery, and since it is recovered, there is no material loss involved. The heavy lubricating oil secured may be processed further by one of the many treating methods now generally in use. In the manufacture of residual cylinder stock from crudes of low asphalt content the process offers a continuous and inexpensive distillation method for the elimination of such asphalt. Because asphalt of extreme hardness can be produced, the finished heavy lubricating distillate has the physical characteristics of a finished residual stock.

During the course of the research work some interesting and unusual products were obtained. In one run, asphalt with a penetration at 77°F. of 67 was further reduced by the process, yielding 50 per cent of asphalt with zero penetration at 77°F. and 50 per cent of heavy lubricating distillate with a viscosity of 475 Saybolt seconds at 210°F. As a matter of academic interest, the process was applied to a residual cylinder stock from Pennsylvania crude, resulting in the practically complete recovery of this stock as a distillate. From the unusual nature of the products mentioned, all of them obtained by a simple continuous distillation process, it is apparent that a wide field is opened to the refiner for the manufacture of new products.



Lummus Company laboratory at Bayonne, New Jersey, showing four-story still house.

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SCIENCE AND TECHNOLOGY

Abstracts prepared in co-operation with the

REFINER AND NATURAL GASOLINE MANUFACTURER

by

THE LESLIE LABORATORIES

Traver Road, Ann Arbor, Mich.

under the supervision of

DR. E. H. LESLIE and DR. H. B. COATS

The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original articles will be supplied at cost by the Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstract, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

Fundamental Physical Data

Thermal Conductivity of Liquids. O. K. BATES. *Jour. Ind. Eng. Chem.* **25** (1933) pp. 431-37.

The thermal conductivities of liquids are of importance in the calculation of heat transmission. The determination of the thermal conductivity is difficult and methods unstandardized. Few coefficients have been determined, and data on variation with temperature are practically unknown. The author reviews methods that have been used, criticizes them, and describes his own procedure. Many experiments were performed with water and a red oil. The conclusion is reached that the method is accurate and that convection error is negligible. The data are presented in tabular form.

The Interfacial Tensions of Mineral Oil Against Various Aqueous Solutions at 40°. W. G. EVERSOLE and DALLAS S. DEDRICK. *Proc. Iowa Acad. Sci.* **38** (1931) p. 163.

An improved apparatus for the direct measurement of interfacial tensions by the drop-weight method has been devised. The use of an automatic recording device permitted making measurements on larger volumes and at slower dropping speeds than were heretofore possible. Preliminary measurements with purified paraffin oil and water solutions of sodium formate, sodium acetate, and sodium propionate have given promising results from the standpoint of accuracy and reproducibility. As the length of the carbon chain increases the interfacial tension becomes lower.

The Saturation Pressures of Steam (170° to 374°). A. EGERTON and G. S. CALLENDAR. *Trans. Roy. Soc.* (London) **231A** (1932) pp. 147-205.

Accurate measurements of the saturation pressure of steam between 160° and 374°C. were made with an apparatus of the continuous flow type. The apparatus and methods of temperature and pressure measurement are described in detail. The results are accurate to 1 part in 6000. They are presented in tabular form giving the saturation pressure in pounds per square inch and in atmospheres for every 5°C. interval. The method was not suitable for the accurate determination of the critical point. However, the indications were that above 374°C. the steam behaved as a superheated vapor.

Graphical Interpretation of the Viscosities of Lubricating Oils at Various Temperatures. J. GROFF. *Mem. Soc. Ing. Civ. France* **85** (1932) pp. 614-27.

The relationship between viscosity as determined kinematically by means of the Redwood, Saybolt, and Engler instruments, is discussed. A nomograph is given by means of which readings at any temperature with any instrument may be converted into those of any other instrument at any other temperature. The viscosity of solutions of known components can also be calculated.

Chemical Composition and Reaction

Thermal Decomposition of Simple Paraffins. F. E. FREY and H. J. HEPP. *Jour. Ind. Eng. Chem.* **25** (1933) pp. 441-49.

The primary reactions of thermal decomposition of n-butane, isobutane, n-pentane, isopentane, 2,2-dimethyl propane, 2,3-dimethyl butane, and n-hexane were studied by causing limited homogeneous reaction and carefully analyzing the products. The primary reaction was followed by rapid hydrogenation and dehydrogenation of the products. If the paraffin formed by the scission of the carbon chain was methane, the balance of the original hydrocarbon appeared as an olefin. If a higher paraffin than methane was formed it appeared in part as olefin and hydrogen. The decomposition of n-pentane and n-hexane resulted in a more profound change and is in agreement with the results to be expected if a chain-reaction mechanism involving the formation and subsequent decomposition of free alkyl radicals were operative. The double bond of any olefin produced remains at the point of rupture. N-paraffins yield only 1-olefins. If olefins were produced through elimination of a side chain from isopentane or similar compound, the double bond at the point of rupture was located in the inner and not in the terminal position.

Manufacture: Processes and Plant

Production of Lubricating Oils by Extraction with Dichloroethyl Ether. J. M. PAGE, C. C. BUCHLER, and S. H. DIGGS. *Jour. Ind. Eng. Chem.* **25** (1933) pp. 418-22.

The authors consider that a lubricating oil should show as little change of viscosity with temperature as possible, should be resistant to oxidation or sludging, and should deposit little carbon. The solvent dichloroethylether is shown to have the solvent power and selectivity required of a solvent for use in the manufacture of lubricants by extraction of undesirable components. By its use the authors have made oils equalling those from Pennsylvania Grade crude in viscosity index and surpassing them in sludging and carbon formation. The raw materials used were Salt Creek and Mid-Continent crudes. The solvent used is non-poisonous, chemically stable, of such low vapor pressure at ordinary temperature that special equipment is not required, sparingly soluble in water, and of low boiling point in comparison to lubricating oils. A commercial "chlorex" extraction plant, based upon 3-stage countercurrent extraction, has been operating successfully at Casper, Wyoming, for a year. The capacity is 500 barrels of finished oil per day. Another plant of 800-barrel capacity is now going into operation.

Candles and Candle Making. D. ALLAN. *Jour. Inst. Pet. Tech.* **19** (1933) pp. 155-75.

The history of the candle and of materials for and methods of making candles is reviewed. Among the subjects discussed are fat saponifica-

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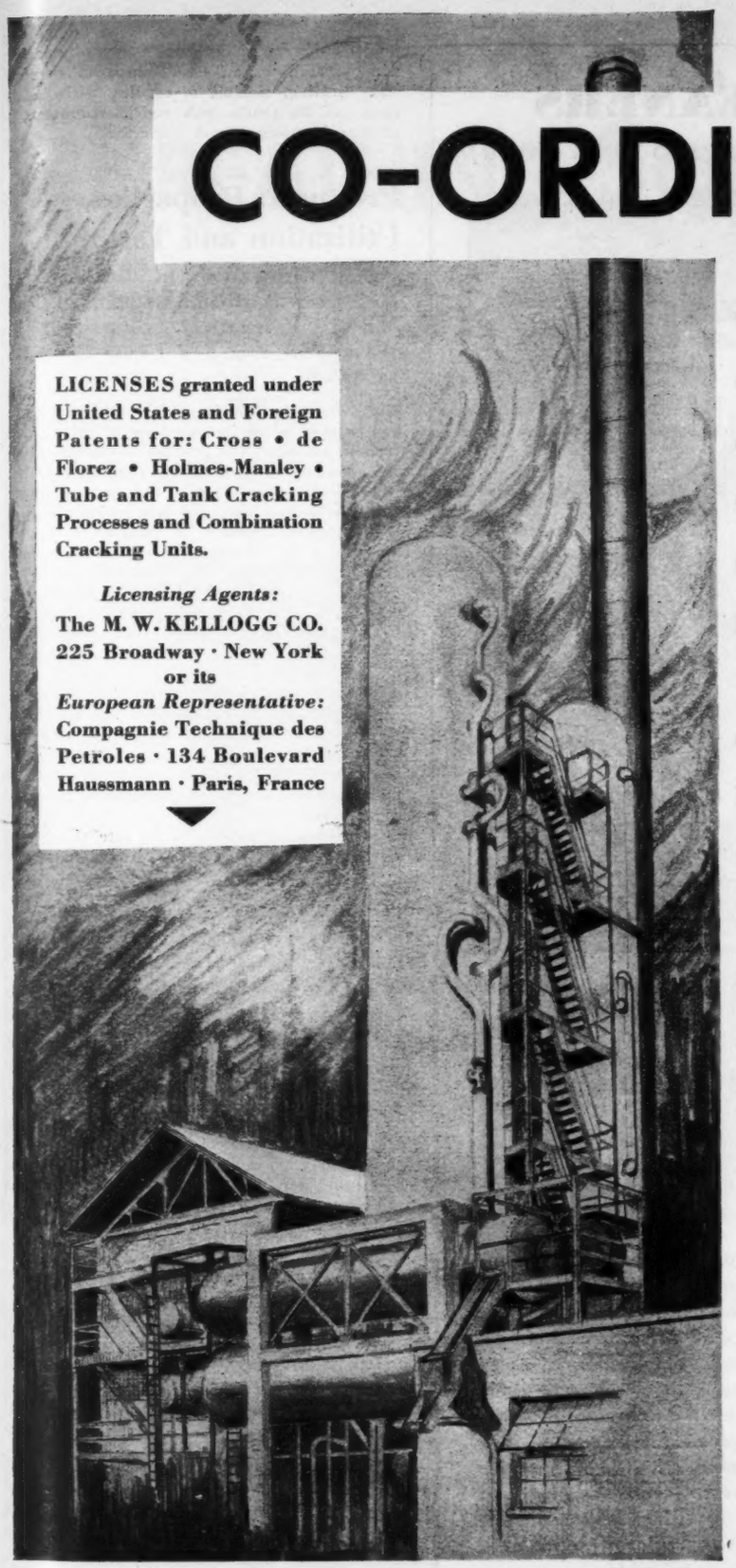

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tion, distillation of fatty acids, use of stearine with paraffin waxes, development of paraffin wax sweating, molding of candles, wicks, mottling, and the candle trade and its requirements as regards materials and properties.

Products: Properties, Utilization and Testing

Gum Formation in Gasoline. I. Measurement of Gum Stability of Gasoline. T. H. ROGERS, J. L. BUSSICO, P. T. WARD. *Jour. Ind. Eng. Chem.* **25** (1933) pp. 397-402.

The demand for fuels of high anti-knock value has resulted in the increased use of vapor-phase cracked gasoline. The problem of evaluating the gum stability of these highly cracked gasolines has become more urgent. The authors report that the Vorhees exidation test, which measures the oxidation behavior of gasoline at 100°C. in terms of the induction period, has advantages over the metal bomb test. Results of the Vorhees test are correlated with gum storage tests in glass bottles at 35°C. and a tentative relationship between this standard storage test and storage in practice is given. Expressed in terms of the time required to form 10 mg. of gum per 100 cc. by A.S.T.M., Method A, which amount of gum is deemed to be the maximum permissible for satisfactory service, an induction period of 400 minutes corresponds to approximately one year of storage life in vented iron barrels at atmospheric temperature in the Chicago region. Although the evidence is that in quiet storage in large tanks the rate of solution of oxygen in the gasoline is the determining in gum formation, it is also true that the protection afforded by low oxygen supply is not a practical insurance against gum formation, for gasoline so stored oxidizes more rapidly once it is taken out of large tank storage and handled.

Distribution of Gum-Forming Constituents in Cracked Gasoline. S. M. MARTIN, W. A. GRUSE, and A. LOWEY. *Jour. Ind. Eng. Chem.* **25** (1933) pp. 381-86.

The rapid deterioration of untreated highly-cracked gasoline under the conditions of ordinary storage is caused by conjugated di-olefins that form peroxides and then act as oxidation catalysts. The oxygen stability of close-cut fractions from a vapor-phase distillate was studied and the gum formation found to vary greatly from one fraction to another. Treatment with maleic anhydride, or sulfuric acid, and also partial hydrogenation rendered the fractions stable to a 38°C. oxidation test. However, a 50°C. oxidation test will show appreciable gum formed from the treated material. This is attributed to the presence of less active cyclic olefins not removed in the treatment.

Methyl Alcohol as a Component of Fuels. A. W. SCHMIDT. *Erdol und Teer* **9** (1933) pp. 74-77.

A new composite fuel containing 70% gasoline, 10% benzole, 10% ethyl alcohol, and 10% methyl alcohol has recently been proposed in Germany. Methanol is prepared synthetically from carbon monoxide and hydrogen and has the advantage of being anhydrous. The author describes experiments on the miscibility relationships and engine performance of the fuel containing methanol. This alcohol is not appreciably soluble in straight-run gasoline but is more soluble in highly cracked gasoline. The addition of ethyl alcohol increases the solubility of methanol in gasoline. In some instances 10% of ethyl alcohol will stabilize up

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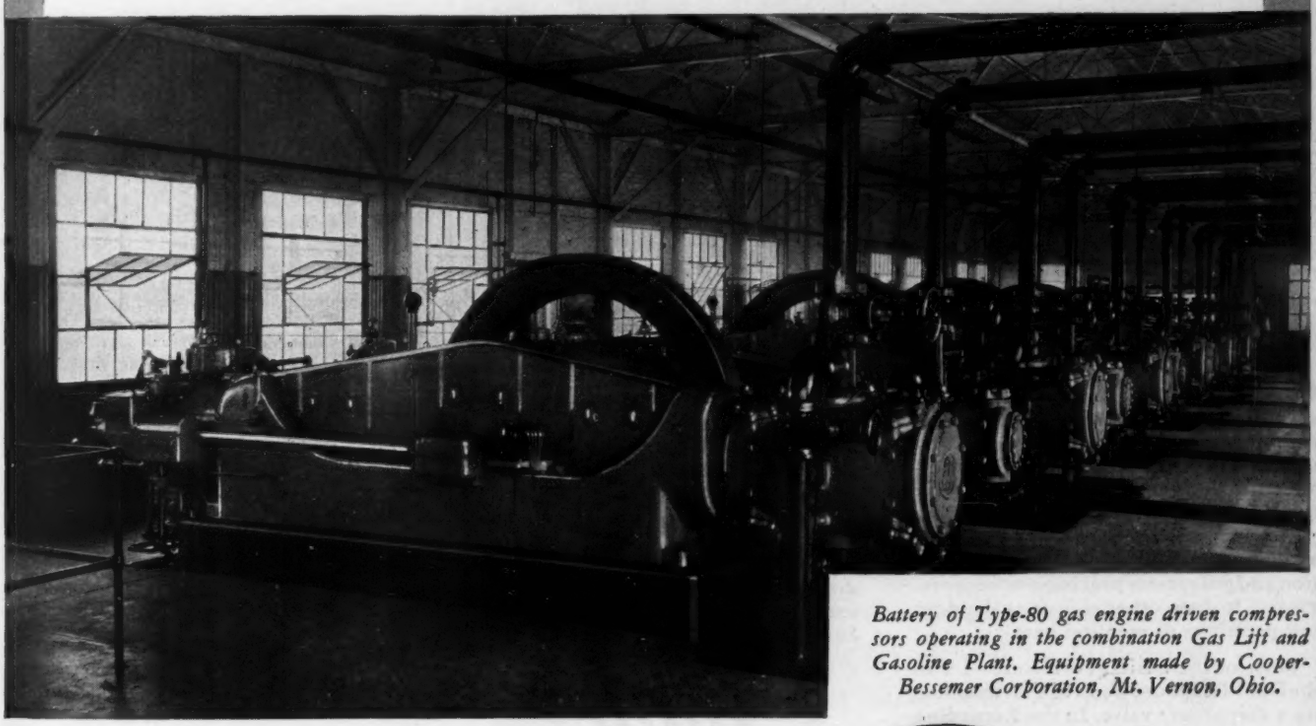


Battery of Type-80 gas engine driven compressors operating in the combination Gas Lift and Gasoline Plant. Equipment made by Cooper-Bessemer Corporation, Mt. Vernon, Ohio.

When a prominent petroleum company required compressor equipment to handle corrosive *still* gas at their midwestern refinery, they warned the manufacturer that special material would be required to handle hydrogen sulphide-contaminated gas... 204 grams per 100 cubic feet.

Cooper-Bessemer recommended and installed the Type-80 gas engine driven compressors pictured above, with all parts in contact with the gas made of Ni-Resist.

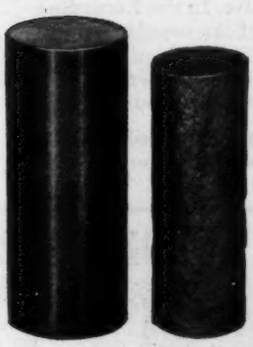
These compressors have now been in almost continuous service for three years. The parts made of Ni-Resist are still operating efficiently, showing only .015" wear. Under comparative service conditions plain cast iron showed several times the wear in a single year.

Ni-Resist is an alloyed cast iron containing 14% Nickel, 6% copper and 2% chromium. The most severe laboratory tests have proved it to have the highest resistance to hydrogen sulphide-corrosion of any cast iron commercially suitable for this kind of application.

Wherever machinery must combat corrosive gases and vapors, acid, caustic salt and alkaline solutions, sea water and chemicals, manufacturers of refinery equipment are using more and more Ni-Resist.

Readily machinable, non-magnetic, highly resistant to wear, heat and corrosion, Ni-Resist is ideally suited for meters, valves, pumps, compressors, flue dampers, pipe and other refinery equipment.

Let us send you our Bulletin No. 208 which gives detailed information concerning the mechanical and corrosion properties of Ni-Resist.



Test samples, originally of the same size, showing comparative corrosive effect after 1 week in 5% Sulphuric Acid at room temperature. Ni-Resist on the left. Cast iron on the right.

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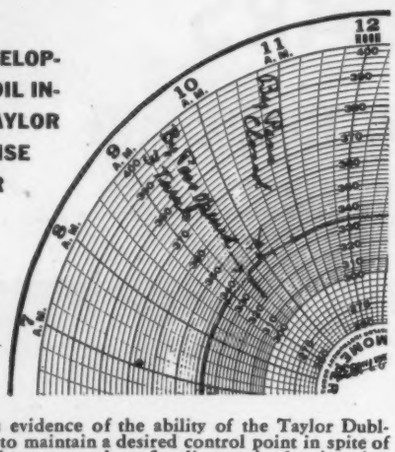

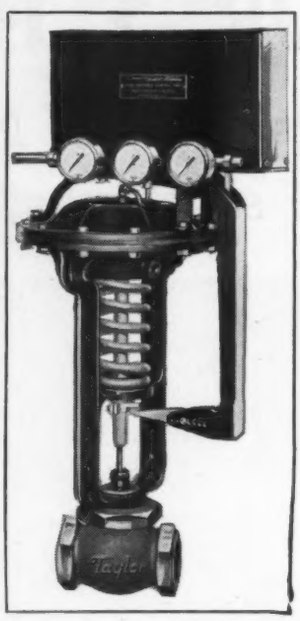

This chart furnishes evidence of the ability of the Taylor Dubl-Response Regulator to maintain a desired control point in spite of load change. The valve was on the reflux line to the fractionating tower of a cracking plant. The by-pass was closed and all reflux went through a 2-inch diaphragm valve. Suddenly the by-pass valve was opened three full turns, causing a 16° drop in temperature. Note how quickly the regulator brought the temperature back to the original setting point automatically. Just as suddenly the by-pass was closed. The temperature built up 6°. But again the regulator restored the setting point.

* * *

At right of chart is the Taylor Dubl-Response Control Unit in position on a Taylor Evenaction Diaphragm Valve.

● The Taylor Dubl-Response Regulator automatically maintains the desired temperature control point in spite of load changes, process time lags, and unbalanced operating conditions in stabilizers, towers or stills. It assures throttling valve action — eliminates "hunting." It automatically overcomes valve stem friction and guarantees precision valve movements. It does other things space does not permit us to mention here.

Most of the basic new features are in the Dubl-Response Control Unit mounted on a diaphragm valve. In the Recording Regulator is one of the most important —a sliding sensitivity mechanism which can be adjusted to meet the process time lag and the effect of load changes.

Mechanism of the Control Unit is rugged and suitable for outdoor installation. Taylor Singl-Duty Recording Regulators now in operation may be used in the system. The Dubl-Response Control Unit may be attached to the Taylor Evenaction Valve you may have in use.

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to 20% of methanol. Ethyl alcohol was found more effective in raising the anti-knock value of gasoline than benzole. Methanol is practically as good as ethyl alcohol. Additions of 20% of ethyl alcohol, methanol, and benzole to a cracked gasoline of 59 octane number raised the octane number 16, 16, and 12 octane numbers, respectively. Data on fuel consumption in two engines of moderate and high compression ratios are given. It was concluded that the use of methanol blend is advantageous only in high compression engines.

Beneficial Effect of Oxidation on the Lubricating Properties of Oil. R. O. KING. *Proc. Roy. Soc.* **139A** (1933) pp. 447-59.

Experiments conducted under conditions promoting oxidation of the lubricating oil and at constant speed and load show that boundary conditions in journal lubrication are of importance. The author suggests that the active or polar molecules formed during the early stage of oxidation form a layer of appreciable thickness on the adsorbed layer and that the friction observed is that on the surface of the built-up layer. The surface diminishes in rigidity in the direction of motion as the thickness of the boundary layer increases, and friction approaches zero as a layer of complete slip tends to be reached.

Synthetic Lubricating Oils. JACQUES WOUDHEYSEN. *Petroleum Z.* **28** *Motorenbetrieb, No.* **49** (1932) pp. 2-3.

Lubricating oils have been prepared from plant products by a secret process. They are colorless, homogeneous, neutral, and contain no tar, or wax. They are immiscible with oil and benzene and do not affect rubber, but are soluble in water. These products have low coefficients of friction, great stability, and are resistant to high pressure and permit operation at lower bearing temperature than mineral oils. The cost of production is low.

Resistance of Mineral Oils to Decomposition by Sunlight. L. W. GREEN and R. E. SCHOETZOW. *Jour. Amer. Pharm. Assoc.* **21** (1932) pp. 1286-87.

The authors find that the rate of deterioration of liquid petrolatum U.S.P. of varying geographical origin and stored in flint glass bottles exposed to the sunlight is variable. The stability of such oil can be measured by short exposures of the oil in such bottles to ultraviolet light.

Experiments with Oil-Testing Transformers. TYPKE. *Erdol und Teer* 9 (1933) p. 61.

Various substances have been proposed for addition to transformer oils to lower their oxidation. The most suitable of these, as judged by laboratory tests, is phenyl-a-naphthylamine. By use of experimental transformers over a period of 3750 hours it was found that the oil containing the amine showed a higher acid number and more sludge than did the oil alone. Comparisons were also made using Russian and American oils without removal of the sulphur and with removal of half the sulphur. The oils with half the sulphur removed deteriorated slightly more than the straight oils.

Preparation of Insulating Oils. TYPKE. *Edrol und Teer* **9** (1933) p. 29.

It has been found that the addition of moderately refined oil to a white oil reduces the tendency to oxidize without giving rise to

sludge-forming properties. However, further results have been obtained by adding a small quantity of methyl alcohol, acetone, or sulphur dioxide extract of a moderately refined oil. For example, an American white oil gave a tar number of 3.7 and no sludge. A mixture of 100 grs. of this oil and 50 grs. of an American spindle oil distillate gave a tar number of 0.34 and a sludge value of 0.09%. A mixture of 150 grs. of the white oil with 0.75 grs. of an extract from 50 grs. of the spindle oil gave an oil having a tar number of 0.02 and that formed no sludge. The extract of the spindle oil was made by use of methyl alcohol.

Paraffin vs. Asphalt-base Oils in Maintaining Egg Grades in Storage. T. L. SWENSON, R. R. SLOCUM, and L. H. JAMES. *Ice and Refrigeration* **83** (1932) pp. 220-22.

The function of mineral oils in the preservation of eggs is to reduce respiration and evaporation through the pores of the egg shell. After nine months in storage all oiled eggs graded higher than unoiled eggs. No difference was observed between oils of paraffin and those of asphalt base. Those oils with pour points higher than the storage temperature were most effective.

New Method for Determining Paraffins in Crude Oil by Means of a Mixture of Ether, Ethyl Alcohol, Butanone, and Phenol. RAFAEL FUSSTEIG. *Z. anal. Chem.* **91** (1933) pp. 418-21.

The author considers that paraffin is present in crude oils in the form of tiny crystals enveloped by protective asphaltic or resinous substances. To precipitate the paraffin it is necessary to add a solvent that will dissolve the protecting envelope but not the paraffin wax. The oil in light naphtha solution is treated with fuming sulphuric acid at 18°C. and then denuded. It is then treated with a mixture of ethyl alcohol, methyl-ethylketone, and 1% phenol at —20°C. Well crystallized paraffin was obtained. The method was tested by the analysis of synthetic mixtures. The solution used works better than the usual alcohol-ether mixture or than acetone.

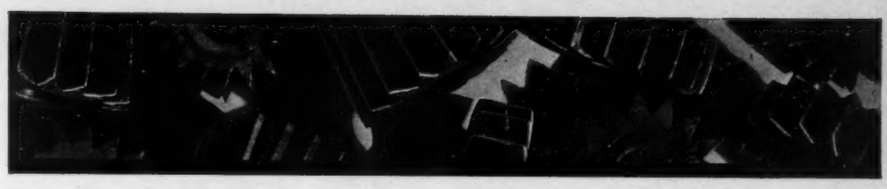
Continuous Viscometer. C. D. MILLER. *Instruments* **6** (1), (1933) p. 2.

The instrument comprises a journal and bearing operating with fixed clearances and at a constant temperature. At constant speed, the pressure of the oil between the journal and the bearing is a measure of the viscosity of the oil and is indicated by a liquid column gauge in which the liquid is the oil that is being tested. Scales are provided reading in absolute units or in Saybolt seconds, Redwood seconds, or Engler degrees.

Natural Gas

The Action of Water Vapor on Methane. C. MATIGNON and M. SEON. *Compt. Rend.* **195** (1932) pp. 1345-48.

Pure methane, or methane mixed with hydrogen, nitrogen, oxygen, and carbon monoxide, yields hydrogen and carbon dioxide when mixed with a large excess of water vapor and passed slowly over catalysts SiO_2, ZrO_2, asbestos sprinkled or impregnated with ZrO_2, ThO_2, Fe_2O_3, $Fe_2O_3 + 10\%\ K_2CO_3$, or Al_2O_3 at 860°, 960°, 1000°, or 1050°C. The best results were obtained by the use of ZrO_2. Using pure CH_4 and ZrO_2 at 1050°, the reaction was complete.



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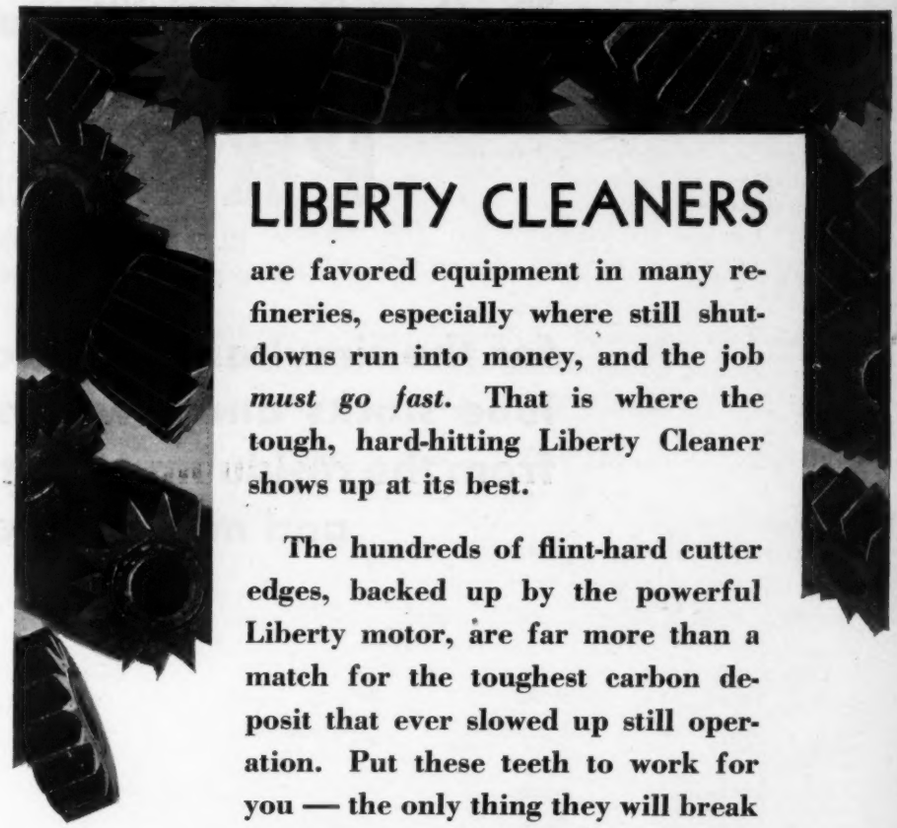

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THE MONTH IN REVIEW

Economics Committee Forecasts Decrease Demand

DAILY production of 2,282,000 barrels of crude oil along with withdrawal of 100,000 barrels daily from storage was recommended to the petroleum industry of the United States by directors of the American Petroleum Institute when the report of the committee of refinery statistics and economics was adopted the afternoon of May 17. Adoption of the report was among the first actions taken by the board when its membership gathered the first day of the mid-year session May 17, 18 and 19. The recommendation covers the six months from April to September 30, 1933.

The report is the work of the subcommittee, which is headed by W. A. Sinsheimer of Henry L. Doherty & Company. The committee on refinery statistics and economics is under the chairmanship of D. J. Moran, president of Continental Oil Company and also vice president of the Institute for the Division of Refining.

The report took no cognizance of the current excessive output of crude oil. This pertinent paragraph, however, was in the presentation:

"Past studies and reports of the committee have not been accorded the importance which they have deserved and as a result, the benefits, which could have been derived from them, have in a large measure been lost. They should not be ignored. No single company within the industry is qualified to prepare a better statistical report than the one now presented. It sounds a definite warning and is worthy of serious study, not only by the industry but in any program for the industry, which may be considered by the federal and state governments."

The consideration of crude oil production was undertaken by the subcommittee because this was necessary in determining the amount of gasoline that should be made during the six months. Concerning motor fuel storage withdrawals the sub-committee said:

"It is interesting, also, to note that in reaching economic fuel stock levels, no more gasoline need be withdrawn from storage between now and September than there was during the same period in 1932."

Motor Fuel Demand

Total motor fuel demand for the six months was set at 211,800,000 barrels, a decline of 5.6 per cent from the estimate for the corresponding period of 1932. Of this total demand 198,000,000 barrels was credited to domestic consumption and 13,800,000 barrels to exports. The reduction in export demand was set at 28.9 per cent, leaving an estimated drop of only 3.4 per cent in domestic demand.

A.P.I. Refining Division Holds Technical Sessions

THE refining division of the American Petroleum Institute at its two sessions during the institute convention at Tulsa last month devoted its time to the study of new developments and methods in the manufacture of lubricating oils and to a symposium on cracking and cracking systems. Five papers were included in the group dealing with de-waxing methods in lubricating oil manufacture, three of which were first technical discussions of new processes and are presented in the technical section of this issue of THE REFINER. With present day demands for improved lubricants from crude petroleum, technical information dealing with developments in processes applicable to this field prove of great interest to refiners. The three processes discussed were centrifugal de-waxing with trichlorethylene, de-waxing in propane with self-refrigeration, and de-waxing oils with benzol acetone.

In the cracking field, which was the topic of the second session of the refining division progress was reported in technical advancement in the production of synthetic motor fuel from heavier distillates, fuel oils and reforming

American Petroleum Institute Committee Summary of Forecast Of Demand, Economic Stocks and Required Supply

April 1, 1933 to September, 1933 (Forecast)
vs.
April 1, 1932 to September, 1932 (Actual)
(In Thousands of Barrels)

ITEM	SECOND QUARTER 1933		THIRD QUARTER 1933		SIX MONTHS	
	Total	% Change	Total	% Change	Total	% Change
MOTOR FUEL						
DEMAND: Total	102,100	— 7.3	109,700	— 4.0	211,800	— 5.6
Domestic	95,000	— 3.3	103,000	— 3.6	198,000	— 3.4
Exports	7,000	—40.5	6,700	—10.2	13,800	—28.9
STOCKS: Change during Period	— 5,026		—10,830		—15,856	
Beginning of Period	60,556		55,530		60,556	
End of Period	55,530		44,700		44,700	
SUPPLY: Total	97,074	—11.5	98,870	— 0.4	195,944	— 6.2
From Imports	—0—		—0—		—0—	
From U. S. Producers	97,074	— 8.1	98,870	— 0.2	195,944	— 4.3
Straight-run and Cracked	89,142	— 7.5	90,990	+ 0.7	180,132	— 3.5
Natural Gasoline	7,652	—14.9	7,600	— 9.8	15,252	—12.4
Benzol	280	— 0.4	289	0.2	560	+ 7.9
CRUDE OIL						
DEMAND: Total	214,340	— 6.5	216,680	+ 1.8	431,020	— 2.5
Export	7,200	—16.3	6,800	— 5.6	14,000	—11.3
Domestic	207,140	— 6.2	209,88[illegible]	+ 2.[illegible]	417,020	— 2.2
Runs to Stills	203,34[illegible]	— 6.[illegible]	206.08	+ 1.7	409,42[illegible]	— 2.7
Used as Such	[illegible].5[illegible]	+ 9.[illegible]	1,50[illegible]	+ 4.2	3,00[illegible]	+ 6.8
Transfers to Fuel (Californi[illegible]	2,30[illegible]	+84.[illegible]	2,30[illegible]	+42.9	4,60[illegible]	+61.1
STOCKS: Beginning of Period	341,76[illegible]		.....		.....	
End of Period	.....		.....		.....	
SUPPLY: Total Required	214,340	— 6.5	216,680	+ 1.8	431,02[illegible]	— 2.5
From Imports	7,000	—66.1	7,000	—32.6	14,000	—46.2

of naphtha. The four technical and informative papers comprising the group were well received and the division membership felt that a vote of thanks was due the authors of the work. These papers will also be found in the technical section of this issue. The rapid development in the cracking field is of major importance to the industry because of the marked influence such progress may have on the demand for crude petroleum in as much as continued improvement in cracking efficiency is bringing about each year additional percentage recovery of gasoline from the barrel of crude.

At a joint session of the Refining and Marketing Division of the Institute the time was devoted to a study of means for increasing consumption of such petroleum products as road building asphalts, furnace and other fuel oils and Deisel fuels. In this cooperative work the two branches of the industry plan more intensive study in recognition of the needed additional outlets or markets for petroleum products.

Judge C. B. Ames, chairman of the

AXTELL J. BYLES
New President American Petroleum Institute

board of The Texas Company, and recently resigned president of the Institute sounded the key-note of the meeting in this address at the general session Thursday afternoon. He placed the burden of demoralization upon the lack of unanimity within the industry itself and urged closer cooperation with state and federal regulatory bodies. He told his audience that these governmental officials have a difficult task and that the task has not been lessened by the multiplicity of "plans" presented by the divided elements of the industry. He particularly appealed to that part of the industry represented by Kansas, Oklahoma and Texas, the three states which have market demand laws, and stressed the need for oil men to define in their own minds what actually constitutes market demand. Further he stated that state agencies are entitled to the solid judgment of the industry in fixing a program, and the industry has never presented a unified program.

Earlier in the meeting the board of directors of the Institute had elected Axtel J. Byles, president of the Tide Water Associated Oil Company, president of the institute to succeed Judge Ames, who had resigned to again join The Texas Company. Mr. Byles will serve the institute as a full time salaried president, having announced his resignation from his former connections and will hold office until January, 1935. Herbert L. Pratt, chairman of Socony-Vacuum Corporation, was elected treasurer of the institute succeeding Mr. Byles who held the office for some time.

Announcing

2 NEW
EXPLOSION-PROOF SWITCHES FOR YOUR SMALLER MOTORS

HERE are two new manually operated G-E switches that provide safe control for full-voltage starting of small motors in explosive atmospheres.

Though small in size, these switches have many of the features distinguishing larger G-E air-break equipment. Their strong, cast-iron cases safely withstand internal explosions; no flame can escape. The switch cannot be held closed on overload, for the protective mechanism operates independently of the handle. Molded Textolite and cadmium-plated parts, and pure-silver contacts assure long life and minimum maintenance.

Complete information may be obtained by requesting publication GEA-1744. Address the nearest G-E office, or General Electric, Dept. 6-201, Schenectady, N. Y.

FOR 3/4- TO 7 1/2-HP. MOTORS, THE CR1062-E3B STARTING SWITCH . . . 3-phase, with double-break contacts to minimize arcing . . . thermal overload protection . . . handle guarded to prevent accidental operation. Both this switch and its companion, shown below, are built to the standards of, and are tested by, the Underwriters' Laboratories for Class I, Group D, locations

FOR MOTORS OF 3/4-HP., OR SMALLER, THE CR1061 STARTING SWITCH . . . single-phase a-c., or d-c., furnished with or without thermal overload protection. Also available for "built-in" mounting on motor housing

301-130

GENERAL ELECTRIC

Technical Subjects at Natural Gasoline Meet

EVENTS of the economic world and developments of the petroleum industry furnished much of the material around which the thirteenth annual meeting of the Natural Gasoline Association of America built its program at Tulsa, May 15, 16 and 17. When Frank L. Chase, vice president of Lone Star Gas Company, Dallas, opened the meeting with his address of welcome the measure looking to federal control of the petroleum industry had not been introduced in congress. Mr. Chase, however, anticipated such a move and dealt at length with the change in the attitude of the American people concerning the entrance of the government into business activities.

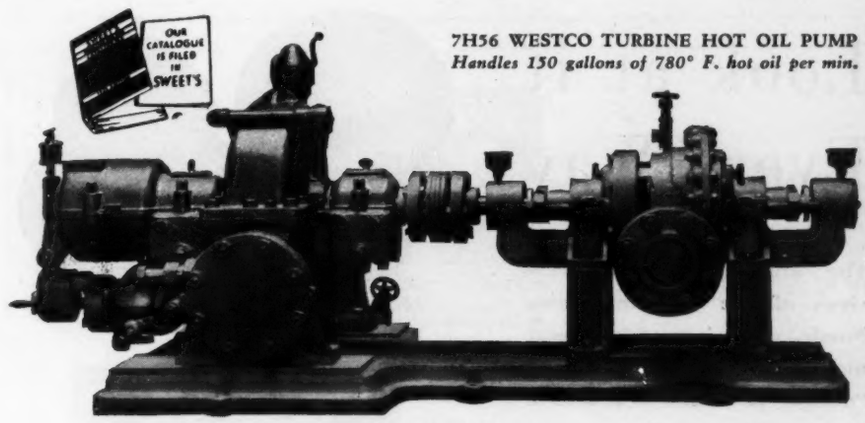
Mr. Chase made it clear that he was not criticizing this trend. He put his position as that of a man who is asking questions. He wanted to know if men in positions at Washington are going to be able to accomplish readily what men within industry have not been able to accomplish.

The move to raise the octane number of motor fuel of the regular grade was criticized by Emby Kaye, vice president of Skelly Oil Company, Tulsa, who read a paper, "Further Consideration of the Disposal of Excess Volatility." In this paper as well as in the discussion that followed, the increased octane number rating was classed as useless. Comparatively few of the automobiles in use today demand octane numbers as high as is proposed for regular gasoline. The industry generally sells premium gasoline to care for the automobiles of higher compression ratios. The question that same out of this discussion was—why increase the octane number of regular gasoline and thus increase its cost when the automobiles can not benefit from it?

This subject was carried still further in the discussion following the paper by Dr. George Granger Brown of the University of Michigan, who discussed "The Preformance of Motor Fuels." Dr. Brown took the position that the octane number questions bids fair to become standardized within a short time. With the petroleum industry settled on its octane rating for motor fuel, he suggested that the time would be at hand for the volatility of motor fuel to take the limelight as a sales appeal. In this he revealed how natural gasoline could continue to hold its own.

The program the first day consisted of the address of welcome by Mr. Chase, the annual address of the retiring president S. S. Smith, Shell Petroleum Corporation, Tulsa, and reports of the standing committees. Mr. Smith reviewed the history of the association and listed the several outstanding tech-

D. C. WILLIAMS



7H56 WESTCO TURBINE HOT OIL PUMP
Handles 150 gallons of 780° F. hot oil per min.

EXPANSION and CONTRACTION

This *Improved* WESTCO TURBINE HOT OIL PUMP allows *full play* to these forces

TWO recent improvements make this valuable feature possible. They are—
1 Symmetrical design of pump
2 New type expansion mounting

Furthermore, our engineers have succeeded in minimizing the hazard of leakage. The secret lies in Westco's vertically split casings which permit the use of a flat, circular casing gasket that is surprisingly small in diameter. The well-known Westco efficiency and dependability remain the same as always.

Does Not Vapor Bind

Westco's Turbine Principle of pumping assures a steady, non-pulsating flow at all times. *It cannot become vapor bound!* This improved Hot Oil Pump also embodies another valuable feature —the water-jacketed stuffing boxes are now definitely relieved of pressure. Packing in a Westco lasts — and lasts, because the oil is cooled before it ever touches the packing.

Corrosion-resisting Construction

Impeller and shaft are made of Stainless Steel. Casings are made of cast steel. However, these pumps can be furnished entirely of Stainless Steel, or other alloys, if a complete corrosion-resisting unit is required. And here Westco's simple design and consequent small metal requirements make for real economy when specifications call for pumps of special metals or alloys. Then too Westco's ability to produce higher pressures in single stage avoids a good deal of costly multi-stage construction.

Send for Details

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nical and economic accomplishments to its credit.

The final paper on this program was "Present Production and Future Trend of Mid-Continent Natural Gasoline", by E. Buddrus, Phillips Petroleum Company.

The morning program of the second day brought C. W. Briles of the Oklahoma Agricultural & Mechanical College before the association to present "Employee Relations in Industry." He urged the speeding of the changing attitude to the effect that men are something more than labor to industry. H. M. Trimble, Phillips Petroleum Company, presented a paper on "Comparison of Anti-Knock Characteristics of Vapor Recovery and Natural Gasoline Blends." S. S. Smith presented the paper by himself and L. S. Gregory, Black Sivalls & Bryson, "Study of Raoult's Law of Equilibrium."

The membership meeting resulted in election of D. C. Williams, Continental Oil Company, Ponca City, as president of the association. W. E. Reardon, Columbian Gasoline Corporation, Monroe, Louisiana, was elected a vice president, as was Ray C. Wheeler, General Petroleum Corporation, Los Angeles. Mr. Wheeler is president of California Natural Gasoline Association. All directors were re-elected.

Entertainment was furnished by the Natural Gasoline Supply Men's Association. Luncheons were served the first two days. The annual dance took place the first evening, while the smoker and entertainment came the second evening.

Gasoline Supply Men May Include W.P.R.A.

W. D. MOORER, president of the Natural Gasoline Supply Men's Association, will name a committee to report on the proposal that the organization enlarge its activities to include the annual meeting of the Western Petroleum Refiners Association. The matter came before the group at the meeting in Tulsa, May 15, when final preparations were made for the entertainment for the annual meeting of the Natural Gasoline Association of America.

Three directors of the association were elected; Paul Raigorodsky of Petroleum Engineering, Inc.; B. W. Vinson of B. W. Vinson Company and G. B. Lane of the Foxboro Company. The three retiring directors were G. M. Bingham of the North American Car Corporation, A. V. B. Chandler of the National Supply Company and W. D. Moorer of the Moorlane Company.

A.S.T.M. Accepts C.F.R. Motor Method

A MOVE of major importance to the automotive and petroleum industries is the adoption by the American Society for Testing Materials of the method heretofore known as the "CFR Motor Method" for determining the octane numbers of gasolines and equivalent fuels used in spark ignition engines other than engines for aircraft. This "motor method" is based on the apparatus and procedure developed by the Cooperative Fuel Research Committee composed of representatives of the American Petroleum Institute, National Automobile Chamber of Commerce, Society of Automotive Engineers, and the U. S. Bureau of Standards who have been studying this problem since 1928.

Since the fuels were to be used in carburetor spark ignition engines, it was immediately evident that a standardized engine would be required as the basic instrument. Its development by the CFR Committee was started more than three years ago, and its present form, described in the A.S.T.M. standard bulletin D 357-33 T, was adopted as the result of several year's experience, and elaborate

Look at it Every Way

The illustrations show three views of the Duriron Mixing Nozzle, which is used in a large number of refineries for acid, "doctor" or caustic treatment or water washing.

These nozzles are installed between pipe flanges, similar to a gasket. That's all there is to it . . . no moving parts . . . no gadgets.

The cross-section shows the mixing action as the oil and treating agent pass up the pipe line and through the nozzle. So simple, so easy to install and take care of. Small friction loss and low back pressure.

Inlet and Outlet Views, Duriron Mixing Nozzle

Enlarged Cross-Section, Duriron Mixing Nozzle

THE DURIRON MIXING NOZZLE

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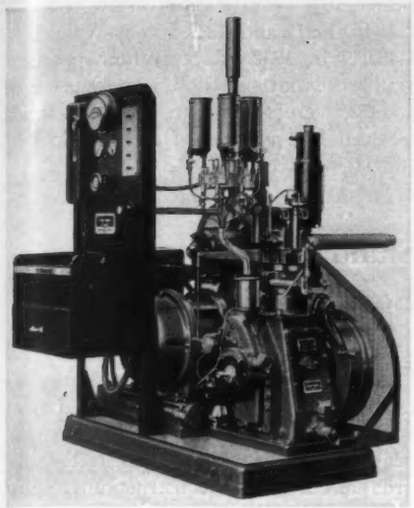

The A.S.T.M.-C.F.R. Fuel Research Unit for Standard Octane Rating of Motor Gasolines.

check tests both with vehicles on the road and in the laboratories of many petroleum refineries as well as in the laboratory of the Waukesha Motor Company, Waukesha, Wisconsin.

The equipment consists of a variable compression, single cylinder, overhead valve engine 3¼-inch bore by 4½-inch stroke equipped with a special type carburetor, electrically heated intake manifold, steam cooling, electric heat control for lubricating oil, and having a moveable cylinder which can be raised or lowered while the engine is in operation to secure compression ratios ranging between 3:1 and 30:1 without any change in the valve adjustments. This engine, together with special ignition, auxiliaries, and indicators is mounted on a common bedplate with a special "synchronous induction motor" which serves as a starting device, and also a loading device for the engine. With this combination, perfect control of the speed, the temperature, ignition advance, and all other controlling factors becomes automatic. Suitable bouncing pin indicators with gas evolution burette or electric indicating knockmeter are all mounted with the control switches on a switchboard panel making the testing set a complete, self-contained unit.

At present, the sole authorized manufacturer of the CFR engine is the Waukesha Motor Company, Waukesha, Wisconsin. Other manufacturers may be approved in the future, but testing laboratories should not purchase engines except from the Waukesha Motor Company without ascertaining whether or not such engines have been approved. Inquiries in this connection should be directed to Dr. R. P. Anderson, American Petroleum Institute Secretary of Committee D-2 on Petroleum Products and Lubricants, 250 Park Avenue, New York City.

More than 250 of these testing units are already in use in testing laboratories throughout the world, and since the adoption of the standard motor method of testing by the A.S.T.M., commercial laboratories everywhere can now purchase these units with confident knowledge that they are buying the authoritative standard instrument for knock rating of gasolines.

Asphalt Consumption Down 16.4 Per Cent

PRODUCERS and manufacturers of petroleum and lake asphalt experienced a declining demand for their products in 1932. The decline of 16.4 per cent in demand is attributed to lessened road construction and decrease in home and industrial construction where roofing materials are used, according to Bureau of Mines Mineral Markets Report No. 205. During the same period the decline was met by a curtailment in production of

Pioneer
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LIME
MFGD. BY
THE HADEN LIME CO.
HOUSTON-TEXAS

The mark of superior quality

We thank you

To those who visited our exhibit at the "Oil Show", we wish to express our appreciation of the interest which prompted the visit, and our thanks for the opportunity of discussing the production and refining operations in which PIONEER OYSTER-SHELL LIME plays such an important role.

Those who were unable to attend the Houston meeting will be equally interested in learning why the unique chemical and physical properties of PIONEER LIME make it especially adaptable to oil refining processes, and how it can increase plant efficiency and reduce production costs.

A letter or card will bring you full information.

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asphalt at refineries bringing about a 16.8 per cent decrease and resulting in reduction of stocks of asphalt held at plants.

The 1932 domestic demand for petroleum and lake asphalt was 2,295,325 tons in 1932, a decline of 449,206 tons from the 2,744,531 tons reported for 1931. Of the 2,474,919 tons of asphalt produced at refineries in 1932, 1,359,372 tons were made from foreign crude oil imported principally from Venezuela, Colombia and Mexico. Sixty per cent of refinery asphalt sold in the past two years has gone into street paving and road building, 29.2 per cent is used by the prepared roofing manufacturers and the remainder goes into a wide variety of minor uses.

Refinery sales of petroleum asphalt were 16.2 per cent less in quantity and 25.2 per cent lower in value in 1932 than in 1931. From 2,873,291 short tons valued at $24,861,339 in 1931, they decreased to 2,408,818 tons, valued at $18,605,117, in 1932.

Exports of natural asphalt, manufactured from the United States decreased 34.8 per cent in quantity and 15.4 per cent in value from 1931 to 1932. The totaled 18,977 short tons, valued at $530,822, in 1931, and 12,365 tons, valued at $448,949 in 1932. Seventy-four per cent of these exports in 1931 and 80 per cent in 1932, were shipped to Europe. Canada received 12.3 per cent of the total in 1931 and 11.3 per cent in 1932.

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PRODUCTS
58% Soda Ash
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Strategically located distributing points ensure prompt delivery of Solvay products with minimum transportation charges.
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Standards Year Book Published

AMERICAN Standards Association, 29 West 39th Street, New York, has published American Standards Year Book recording establishment during the past year of 31 new national industrial standards affecting the construction, mining, oil, radio, electrical, and almost all major industries in the United States. The year book is issued as a record of the cooperative achievement of nearly 3000 scientists and engineers representing more than 500 national technical trade organizations in the development of a unified system of basic technical standards for industry. This work has gone forward without abatement during the past few years despite the depression.

Daniel C. Roper, United States Secretary of Commerce, in a foreword to the year book points out the importance of industrial standards in commerce. "National recognition of such standards will remove misunderstandings and expedite commercial transactions. Especially is this important in interstate and international trade when the buyer is unable to inspect personally and select the commodities offered by the seller," he states.

Viscosity Temperature Zone Index Chart for Oils

A VISCOSITY temperature zone index chart with inserted A. P. I. gravities at 60°F. and S.A.E. viscosity numbers for lubricating oils has been prepared by Sinclair Refining Company, 45 Nassau Street, New York, in 17 x 22 inch size for either wall or desk use. It is printed in red and green on tough, heavy, linen reinforced paper, and is available at one dollar a copy through C. M. Larson of Sinclair Refining Company. A letter size chart has also been prepared and will be furnished with the large chart. A valuable feature of the small chart is the viscosity blending and dilution chart printed on the reverse side, with instructions as to its use.

Viscosity classification is becoming of increasing importance, not only as an indication of the stability of lubricating oils at high and low temperatures, but also because of its bearing on volatility and consumption in service.

PLANT ACTIVITIES

Refinery: Supreme Refining Company is completing erection of 250-barrel skimming plant in Gladewater section of the East Texas field.

Refinery: G. E. Holmes and associates, Gladewater, Texas, erecting a small skimming plant about a mile east of Gladewater, East Texas field.

Gasoline Plant: Magnolia Petroleum Company, Kings Mill, Gray County, Texas Panhandle, erecting 25,000-gallon natural gasoline plant, moving material from plant at Le Fors, Gray County. V. L. Dickinson, superintendent this district with offices at Pampa.

Re-organized: Cosden Oil Corporation of Maine has succeeded Cosden Oil Company. Erecting Winkler-Koch combination cracking-skimming unit at company's Big Spring, Texas refinery, estimated cost $250,000. E. J. Mary, superintendent. J. S. Cosden, president, W. D. Richardson, vice president and sales manager, other vice presidents are A. G. Reed, C. D. Hartman, T. R. Hawley, and Russel McGee is secretary-treasurer.

Refinery: Union Development Corporation, formed by C. M. Johnson, consulting engineer, Houston, formerly with Crown Oil & Refining Company and G. M. Campbell, formerly with United Gas Public Service Corporation, is rebuilding Union Gasoline Company's plant at Houston to operate on Conroe light crude. Capacity 500 barrels daily.

Refinery: Rainbow Oil & Refining Company, building a small refinery at Grand Lake, two miles south of Conroe on the Houston-Conroe highway.

Refinery: Munhall Refinery Company, building small skimming plant near the Conroe oil field, Montgomery County, Texas, located at Grand Lake.

Refinery: Rusk Gasoline Company started construction, 2500-barrel skimming plant, one mile north of Overton, East Texas field. J. H. Edwards, H. H. Coffield, Geo. P. Mann and associates, formerly owners of Rusk Refining Company which was recently purchased by Oil Refineries, Inc., are organizers of the new concern.

Refinery: Gilmore Oil & Refining Company, erecting 150-barrel skimming plant, Gilmore, Texas, near the East Texas field. B. L. Lee, Chester Lee and Crawford Taff, principle owners.

Operating: Dutch Rose Refining Company, Gladewater, Texas, was added to active list of East Texas refineries late in May, upon completion of its 200-barrel skimming unit. Frank Traywick, owner.

Acquisition: Southwest Refining Company, Electric Building, Fort Worth, Texas, formed early in May by Sam C. Yingling, president, and associates, took over the 250-barrel plant of Tren-Tex Refining Company, T. & P. Railroad, Trent, Texas, and increased capacity to 500 barrels. Plant connected to Noodle Creek field, Jones County, by a six-mile two-inch pipe line.

Refinery. Hiothane Refining & Gasoline Company, controlled by M. M. Travis and Cornelius Kroll, Tulsa, operators, building 3000-barrel skimming plant one mile northeast of Kilgore, East Texas field, and planning removal of gasoline plant from Oklahoma to operate in conjunction with the refinery.

Refinery: Bee Oil & Refining Company, Pettus, Texas, building 1000-barrel topping unit. H. N. Carter, president and manager of sales, M. V. Reeves, vice president and general manager, C. L. Reeves, secretary and treasurer.

Operating: Rado Refining & Producing Company, H. B. May president and Walter K. Campbell, vice president, operating 500-barrel skimming plant, McAllen, Texas. J. P. Ryan, superintendent.

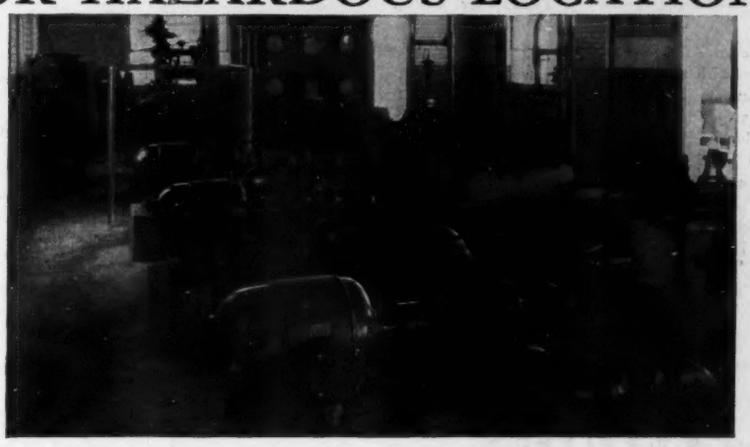
Improvements: Panhandle Refining Company, Wichita Falls, Texas, has completed improvements involving the combining of its skimming and cracking operations in one unit. Uses Dubbs cracking units and combined operations eliminates use of shell still battery.

Operating: Associated Oil Company, Associated, California, has completed erection of 10,000-barrel combination viscosity breaker and cracking unit, Tube and Tank type, installed by E. B. Badger & Sons Company.

Refinery: Paul Huber is building a 500-barrel skimming plant at Casper, Wyoming, to operate on Pilot Butte, Fremont County, crude produced by Argo Oil Company.

Cracking Plant: Compania Mexicana de Pe-

FOR HAZARDOUS LOCATIONS



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GENERAL ELECTRIC

troleo "El. Aguila" S. A. (Mexican Eagle) Mexican subsidiary of Royal-Dutch group, is installing a large Gyro vapor phase cracking unit, with absorption and stabilization facilities, and a new distillation unit, contract to Alco Products, Inc., reported cost $1,000,000. Gyro capacity 2000 barrels, refinery capacity 30,000 barrels.

Power Plant: Hancock Oil Company, Long Beach, California, has awarded contract to Southwestern Engineering Corporation for installation of two high pressure Southwestern boilers to increase capacity of steam generating plant.

Rebuild: Caminol Oil Company, Santa Fe Springs, California, is rebuilding equipment damaged by fire early in May, awarding contract to Southwestern Engineering Corporation.

Refinery: Pan-American Refining Corporation, subsidiary of Pan American Petroleum and Transport Company, recently organized under laws of Delaware with capital stock of $15,000,000 has been granted a permit to operate in Texas. Will build refinery at Texas City, Texas.

Refinery: Allegheny Refiners, Inc., has signed contract with Leader Industries, Inc., for construction of complete 750-barrel plant at Bolivar, New York. Plant will operate on dark Pennsylvania crude exclusively. Wax plant planned at later date. Pipe still units, shell stills, two 250 horsepower boilers, turbo generators, power house, filter house, burner house, wax and centrifuge plant, sweating house, agitators, barrel and stock house, office and laboratory, machine shop, loading racks, pump houses and accessories, 80 tanks from 300 to 5000 barrels capacity, included. Plant design by Dr. E. H. Leslie, head of technical staff for Leader Industries, Inc.

Distillation Unit: Bradford Oil Refining Company, Bradford, Pennsylvania, has completed construction of a distillation unit which features use of steam under closely controlled conditions instead of vacuum, designed by Dr. E. H. Leslie, erected by Leader Industries, Inc.

Operating: Marathon Oil Company is operating the new cracking installation and other equipment erected by M. W. Kellogg Company at its Fort Worth refinery.

Reconditioning: Independent Oil & Refining Company, present owners of Laurel Refining Compay, Laurel, Montana, reconditioning the plant and will operate early in June. Capacity 5000 barrels with cracking facilities.

Refinery: The River Dome Oil Company, Roundup, Montana, is building a small topping plant to run Cat Creek crude and market locally.

Refinery: Zenith Oil Company has filed notice of intention to build a topping plant near Fellows, California, in the Midway district.

Improvements: Rio Grande Oil Company, Vinvale, California, plant completed installing pressure distillate stabilization and absorption gasoline recovery equipment, both installed by Parkhill-Wade, Inc., successors to J. A. Campbell Company.

Improvements: The Norwalk Company, Santa Fe Springs, California, gasoline absorption plant has completed addition of stabilization and accessory equipment, designed by Parkhill-Wade, Inc., successors to J. A. Campbell Company.

Operating: Standard Oil Company of California, is operating its Middle Dome, Kettleman Hills gasoline plant, completed last year considerably ahead of first well completion. Capacity, 50,000,000 feet, operating at 25,000,000 feet.

Move Plant: Mohawk Oil Company is dismantling its Venice, California, absorption plant to rebuild near Bakersfield, to handle gas produced from Mountain View field, Kern County.

Acquisition: The Texas Company has acquired seven per cent interest in Great Lakes Pipe Line Company, piping gasoline from Oklahoma to Chicago and the Twin Cities. Skelly Oil Company acquired three per cent more—now having 16 per cent interest. This was made possible by sale by Barnsdall Corporation of half of its 20 per cent interest in the concern. Other owners are Continental Oil Company, 31.2 per cent; Mid-Continent Petroleum Corporation, 20 per cent; Pure Oil Company, 10 per cent, and Phillips Petroleum Company, five per cent.

Lube Plant: Phillips Petroleum Company, Okmulgee, Oklahoma, refinery reported planning extension and modernization of its lubricating oil manufacturing department.

Operating: Falcan Refining Company, Great Bend, Kansas, 500 barrels skimming capacity started operating, processing Chase Pool crude.

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EMPIRE METERS . . . sturdy, dependable, lastingly accurate, *and economical to operate* . . . the original meter (still unequaled) of the oscillating piston type . . . the only meter that has the famous EMPIRE BALANCED PISTON. Catalogue 126 on request.

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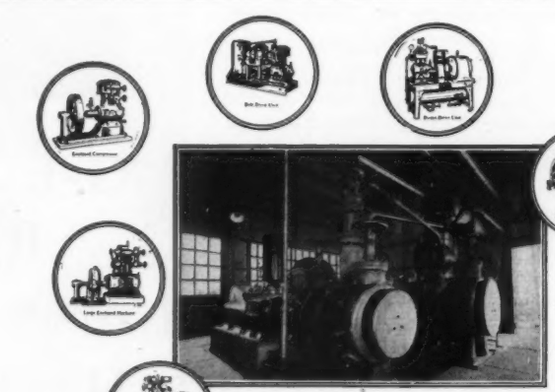

Frick Type J Compressor at Bayonne, N. J. plant of Tidewater Oil Co.

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ICE MACHINERY SUPERIOR SINCE 1882

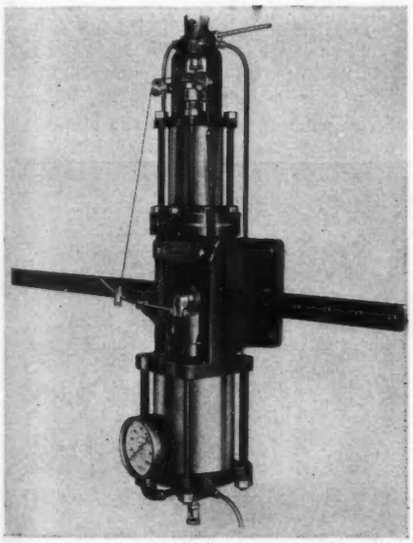
New Equipment for the Modern Plant

1. Combustion Regulator

MOREY & JONES, LTD.

Morey & Jones, Limited, 922 South Hemlock Street, Los Angeles, California, announce a new regulator for combustion control for steam boilers.

The regulator employs a 4½-inch cylinder and an operating arm having a travel, or movement, on its outer end of 12 inches, sufficient for all needs of various types of damper control. A pilot valve on top of the regulator assembly causes sensitive, positive control of steam pressure within close limits, according to the manufacturer.



Morey & Jones Combustion Regulator

The pilot valve spring is set to balance the required boiler pressure imposed onto the pilot diaphragm. As the pressure rises above the set point, steam is admitted through the pilot valve into the cylinder of the regulator. The piston then moves and closes down the damper and firing valves to a point required by the load on the boiler—with the compensator acting to prevent too great a movement. If the steam pressure falls below this set point, a reverse action takes place.

No. 27 regulator is suitable for controlling boilers operating under steam pressures ranging from three to 450 pounds per square inch, according to Morey & Jones, Limited.

2. Turbine Pumps

ROOTS-CONNERSVILLE-WILBRAHAM

Roots-Connersville-Wilbraham, Connersville, Indiana, announces a complete new line of turbine pumps with capacities ranging from 5 to 300 gallons per minute, at heads up to 350 feet. One feature of the pump is the taper-edge impeller which gives ability to vary quantity while the pump is running. Manufacturer states that there is a slight increase in capacity as the head falls, with a noticeable decrease in power consumption. The taper edge impeller may be adjusted to give volume required at lower heads while taking full advantage of savings in power consumed. Suction and discharge openings are both located in the main pump housing, facilitating disassembly for cleaning and without disturbing pipe connections. The pumps are furnished in corrosion resisting metals or alloys, thus adapting them for service in many difficult industrial applications.

3. Control Instrument

THE FOXBORO COMPANY

The Foxboro Company, Foxboro, Massachusetts, recently added a new combination instrument for recording and controlling pressure and recording flow. The pressure controlling mechanism is of the Stabilog type, permitting full-floating valve action. The flow meter construction is identical with later developments in flow meter design. The manufacturer states that a number of these instruments have found application on gas pressure regulation where flow measurement is essential, such as in back pressure regulation with metering of tail gas from oil refining processes, and on steam lines and fuel gas lines where pressure reduction is important and metering essential. The instrument is equally adaptable to pressure regulation and metering of liquids and is used on water lines, brine lines, and similar services.

The combination pressure Stabilog and recording flow meter is available in either the flush type case for mounting, or in surface mounted case. It is equipped with weather-proof door construction and the case may be built gas-tight and vented to operate on natural gas instead of compressed air.

4. Alloy for Acid

THE DURIRON COMPANY, INCORPORATED

The Duriron Company, Incorporated, Dayton, Ohio, announces an alloy which will handle all concentrations of hydrochloric acid at all temperatures up to the boiling point, without any appreciable loss.

Heretofore the only metal alloys which would withstand the corrosive action of hydrochloric acid have been very expensive, so much so that many types of handling equipment have been impractical from the cost viewpoint, according to the manufacturer. This new alloy is comparatively inexpensive.

Oil producers will probably be interested in this alloy in connection with the hydrochloric acid method of increasing well production.

5. Splash Proof Motor

IDEAL ELECTRIC & MANUFACTURING COMPANY

Ideal Electric & Manufacturing Company, Mansfield, Ohio, announces a splash proof motor, especially designed for use in places where water or other liquids may be splashed on the motor, or where the equipment is frequently washed down with a hose as a stream of water striking the motor at any angle or even

Ideal Explosion Proof Motor

— — — — — — — — *MAIL COUPON* — — — — — — —

REFINER AND NATURAL GASOLINE MANUFACTURER,
Houston, Texas, U. S. A.

Please see that I am supplied, without obligation, additional information on New Equipment Items Nos. .....described in June, 1933, issue of REFINER.

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Company .....

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- ☐ Damper Regulators
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- ☐ Pump Governors
- ☐ Float Valves
- ☐ Swing Joint Fittings
- ☐ Thermostats
- ☐ Balanced Valves
- ☐ Control Valves

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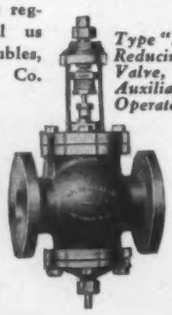


Type "A" Reducing Valve, Auxiliary Operated

Have you received data on the four types of self-contained temperature regulators which we recently developed? Simply check "Temperature Regulators," above, and we will mail it.

pointed directly into the ventilation duct as illustrated will not wet the motor windings.

Baffles placed in the air ducts remove all spray from the air entering the motor and keep the motor windings dry at all times. The motor is simply a standard induction motor using special bearing brackets.

These motors are made in all sizes from one to 200 horsepower as squirrel cage induction motors and meet any and all classifications of torque and inrush requirements. They are also available as cross-the-line start motors up to 200 horsepower and can be supplied as unity (100%) or 80% leading power factor induction motors in all sizes.

6. Protective Coating

MILDON ENGINEERING COMPANY

Mildon Engineering Company, 25 Broadway, New York, have developed a furnace glaze or vitrified coating, placing it on the market under the trade name of "Fire-Kote". The product is used for protective coating of furnace linings, arches, baffles, and air cooled walls. It does not contain silicate of soda and the manufacturer states that it fuses progressively between 1200° F. and about 2800° F. and does not refuse to run at much higher temperatures, having been tested about 3400° F. It is stated that the product becomes an integral part of the refractory and will not check or flake off. The refractory life is much prolonged and frequently doubled or trebled, according to the company.

7. Fire Hose Process

B. F. GOODRICH RUBBER CO.

The B. F. Goodrich Rubber Company, Akron, Ohio, announces the "Hydroseal" treatment of cotton jackets for its line of fire hose for industrial use.

By use of the Hydroseal process every cotton strand in the hose jacket is impregnated with the wax and gum mixture. It is made possible by the process through a method of damming off, thereby preventing the wax and gum mixtures reaching the rubber backing and tube. Because of this method, adhesion of the tube to the jacket is not affected. The manufacturers are also able to thoroughly impregnate the inner jacket of double jacket hose.

Electrically Driven Centrifuges
Hand Centrifuges

WRITE

WILLIAMS, BROWN & EARLE, Inc.
Manufacturers of Laboratory Apparatus
918 Chestnut St. Philadelphia, Pa.

Treatment contains a fungicide chemical which combats mildew. Other advantages cited by the manufacturer are: Insures adequate adhesion between jacket and lining with complete impregnation of cotton in the jackets, without materially affecting flexibility; affords a hose jacket with much higher resistance to water absorption the Hydroseal cotton jacket does not adhere tightly to ice; Hydroseal process permits penetration of wax and gum treatment of such nature that circular woven jackets can now be treated satisfactorily, giving much long life to treated hose.

8. Observation Port

PLIBRICO JOINTLESS FIREBRICK COMPANY

Plibrico Jointless Firebrick Company, 1800 Kingsbury Street, Chicago, announces an inexpensive but efficient observation port for inspection of furnace conditions. The port is provided with a divided cover which opens at a touch on the handle and

Plibrico Observation Port

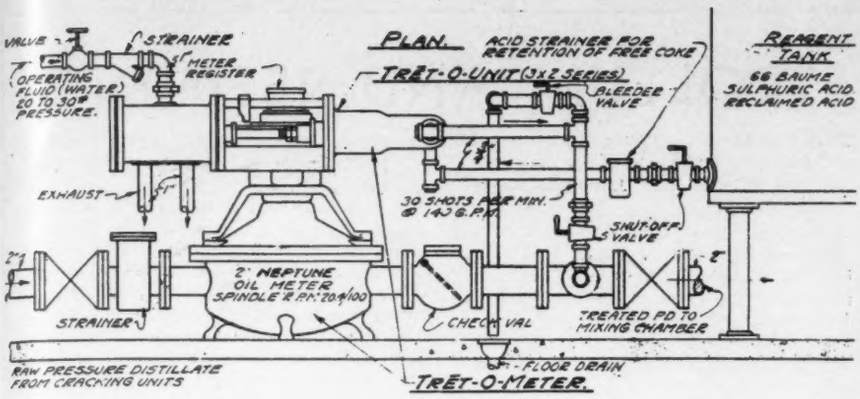
closes automatically when the handle is released. It is impossible for the operator to leave the port uncovered and permit an inrush of excess air. The overlapping sections of the cover close tight, practically eliminating air infiltration. The port is also equipped with a glass to protect the eyes of the operator. This glass is made of blue Pyrex to resist heat and diffuse the glare.

9. Tret-O-Unit

% PROPORTIONEERS %, INCORPORATED

% Proportioneers %, Incorporated, 737 North Michigan Avenue, Chicago, announce Tret-O-Unit for proportional processing of fluids. Treating, sampling or other proportional processing of fluids can be automatically accomplished with precision.

The Tret-O-Unit measures the proper per centage of chemical, builds it up to the necessary pressure, and injects it into the untreated fluid, or removes



from the pipe line a uniform continuous sample. The reagent injection can be readily changed in small increments from minimum to maximum capacity by special stroke-length adjustment. When once set by the operator, the ratio of reagent in-put to fluid thru-put remains constant.

In installation, the Tret-O-Unit is broadly applicable to any fluid meter, rotor, pump or other flow responsive equipment. In conjunction with most standard meters the Tret-O-Unit gearbox can be interposed between the meter body and the meter register so as to regulate the stroking rate of reagent pump. Installations of this type have been made on most standard makes of meters, on both new meters and on existent meters years after original installation.

Many fluids however cannot be handled by meters because of the corrosive, abrasive, viscous or high-temperature characteristics of the throughput to be treated. For this contingency the Roto-Flo, an external bearing type flow-responsive rotor, is offered.

Rotor in Tret-O-Meter System

10. Seamless Boiler Tubes

JONES & LAUGHLIN STEEL CORPORATION

Jones & Laughlin Steel Corporation, Pittsburgh, has announced a complete line of hot rolled seamless steel boiler tubes. A push-bench mill, the only one of its kind in this country, is used for manufacture. The forging action of this mill is claimed to be excellent, the quality of the steel being improved with each step in the process.

These J & L boiler tubes have exceptional ductility and lend themselves quite readily to rolling in and beading operations. A striking characteristic of J & L Boiler Tubes is their handsome appearance, the surfaces both inside and outside being unusually smooth. This, the manufacturer states, is an important factor in retarding corrosion when the tubes are in use and in minimizing depreciation while they are held in stock.

11. Steam Atomizing Burner

BABCOCK & WILCOX COMPANY

Babcock & Wilcox Company, 85 Liberty Street, New York, announces a new steam atomizing burner to handle fuels such as heavy oil, tar, pitch and acid sludge. Steam is admitted to the annular space around a central fuel barrel and is projected across each outgoing stream of fuel at the nozzle plate, thus affecting complete atomization and resulting in a short turbulent flame when use with the B & W Burner Register. A single nozzle plant is used for all capacities from the maximum to the minimum ratings, variations in capacity being accomplished by varying the fuel and steam pressures.

12. Compressors

ALLIS-CHALMERS MANUFACTURING COMPANY

Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin, announces a series of single-stage water-cooled rotary air compressors and dry vacuum pumps for pressures up to 60 pounds per square inch gauge, and vacuums up to 28.5 inches Hg. (referred to 30 inch Barometer). The manufacturer states that due to the relatively high speeds made possible by the employment of rotary motion the "sliding-vane" compressors and vacuum pumps may be direct-connected to standard electric motors and occupy very small space in proportion to capacity. Operation is smooth and vibrationless and air delivery continuous, without pulsations. Design is simple, involving no valves or complicated motions. Maintenance and attendance requirements are low. Foundations are simply and inexpensive. All working parts are totally inclosed, but easily accessible.

13. Hot Oil Pump

GOULDS PUMPS, INC.

Goulds Pumps, Inc., Seneca Falls, New York, announces the addition of a new single-stage centrifugal hot oil pump to its line of pumps for the oil industry. Built in four sizes, for handling capacities up to 500 g.p.m., adequate provision has been made in the design for efficient operation under the severe service encountered in modern refinery practice.

The casing is split at a 45° angle which allows self-venting top discharge and at the same time gives the usual ready accessibility for inspection of impeller and wearing rings. For temperatures up to 450°F., cast iron casing is furnished; while for temperatures up to 1000°F., electric carbon steel or alloy steel casing is used depending on requirements of service. Suction chamber is vented and stuffing box and bearing are water cooled. Shaft is furnished with sleeves of nitrated nitralloy.

Items About Manufacturers

John P. Harris, manager of the Chicago office for Industrial Chemical Sales Company, Inc., New York, was elected president of the American Oil Chemists Society at its recent annual meeting in New Orleans.

Globe Stainless Tube Company, Milwaukee, announces that T. Holland Nelson, Widener Building, Philadelphia, has been retained as metallurgical adviser to the company.

Peabody Engineering Corporation announces the removal of the main offices of the company from 40 East 41st Street to 580 Fifth Avenue, New York, where it is to occupy a large part of the 26th floor. The company recently purchased a factory in Stamford, Connecticut, where all Peabody equipment will be manufactured.

Mildon Engineering Company has moved into new offices in the Cunard Building at 25 Broadway, New York.

Waterous Company of Saint Paul, Minnesota, manufacturers of rotary pumps, announces ap-

BOOKS ON PETROLEUM AND REFINING

HEAT TRANSMISSION—*William H. McAdams.*

A comprehensive treatise sponsored by the Committee on Heat Transmission, National Research Council, dealing with the various fields of heat transmission, based on considerable unpublished data as well as on a critical examination of the literature. Contains authoritative correlations for the various important cases of heat transfer with 33 examples of the application of the recommended relations. Published January, 1933. Price, $5.00.

CHEMISTRY AND TECHNOLOGY OF CRACKING—*A. N. Sachanen and M. D. Tilicheyev.*

Published in December, 1932, this book is a valuable addition to the library of those interested in cracking unit design, construction, or operation, or in the general subject of the chemistry or cracking. This late work covers thoroughly the fundamental features of cracking, chemistry of cracking, chemical composition of cracked products, properties and chemical treatment, the principle cracking systems, and includes an excellent chapter on the hydrogenation of petroleum products.

Price $8.00

BUTANE-PROPANE HANDBOOK — *Arranged and Edited By Geo. H. Finley, Editor Western Gas.*

The first edition of the Butane-Propane Handbook, published November, 1932, is the only work of its type and presents a most thorough treatment of the liquefied petroleum gases industry. Contents: A Chronology of Liquid Gas Development, Physical Properties of the Liquefied Petroleum Gases, Properties of Butane-Propane Mixtures and Relation of Properties to Temperatures, Composition and Analytical Determination of Liquefied Petroleum Gases, The Manufacture of Liquefied Petroleum Gases, Transportation of Liquefied Petroleum Gases, The Use of Butane and Propane with Manufactured Gas, Central Plants for Butane-Air Service, Central Plants for Undiluted Butane-Propane Vapor Service, Liquefied Petroleum Gases as Industrial Fuels, Appliance Utilization of Liquefied Petroleum Gases and Bottled Gas Distribution of Liquefied Petroleum Gases.

Price $5.00

PRINCIPLES OF CHEMICAL ENGINEERING—*Walker, Lewis and McAdams.*

This Standard Text Book and reference presents principles of stoichimetry, describes phenomena accompanying flow of heat, flow of fluids, together with laws governing these operations, discusses fuels and their combustion, treats, with crushing, grinding, mechanical methods for separating materials, filtration and vaporization, absorption and extraction.

Price $5.50

THE CATALYTIC OXIDATION OF ORGANIC COMPOUNDS IN THE VAPOR PHASE—*L. F. Marek and Dorothy A. Hahn.*

The latest work on Oxidation brings the data down to 1932, comprehensively covering the literature dealing with oxidation processes. Contents: Catalysis, Catalytic Decomposition of Alcohols, Oxidation of Alcohols to Aldehydes and Acids, Reactions Involved in the Synthesis of Hydrocarbons and Alcohols from Water Gas, Oxidation of Methanol from Formaldehyde, Oxidation of the Gaseous paraffin Hydrocarbons, Oxidation and Hydration of Olefins and Acetylene, Oxidation of Petroleum Oils, Production of Hydrogen from Methane, Surface Combustion, Knocking in Internal Combustion Engines, Oxidation of Benzene, its Derivatives, Naphthalene Anthracene and Miscellaneous Polynuclear Compounds, Apparatus.

Price $9.00

WORLD PETROLEUM DIRECTORY—*Russell Palmer, World Petroleum.*

A new directory covering oil companies in this and 103 foreign countries, listing American oil producers, oil refineries, natural gasoline manufacturers, pipe line operators, oil marketers, jobbers, compounders, grease and asphalt producers, refining companies, location of plants, capacities, company officials and operating personnel. Headquarters of oil companies over the world are given, offices, financial data, and other pertinent information.

Price $10.00

THE SCIENTIFIC PRINCIPLES OF PETROLEUM TECHNOLOGY—*Dr. Leo Gurwitsch and Harold Moore, 1932 revised edition.*

The original translation of Gurwitsh's second edition (1925) appeared in 1926, and in response to a wide appeal the preparation of a second edition was undertaken by Harold Moore and C. I. Kelly, to include data on technical and scientific work on petroleum to 1932. The well known standard reference work is the most comprehensive treatment of petroleum technology now available.

Price $8.00

PETROLEUM DICTIONARY — *Hollis P. Porter.*

A thorough and comprehensive glossary of terms used in the producing, refining and marketing branches of the petroleum industry. The Petroleum Dictionary of 234 pages presents over 3000 terms and definitions. It is offered those engaged in the industry as a first edition, the author having in mind the compilation and publication of future editions as the need arises. Includes many new words and expressions used in the description of newly developed processes and appliances.

Price $3.00

CHEMICAL ENGINEERING, UNIT PROCESSES AND PRINCIPLES—*Edited by John C. Olsen.*

A broad practical treatment of unit processes, selection of best type of equipment for the particular process. Includes the following chapters: Heat and Power, Flow of Heat, Evaporation, Principles of Fractional Distillation, Steam Distillation, Dry Distillation and By-Product Recovery, Filtration, Drying, Electric Heating, Catalytic Heating, Absorption of Gases, Electrolysis, Separation of Solids and Liquids from Gases, Materials, of Construction, Cost, Financing and Location.

Price $5.00

ELEMENTS OF CHEMICAL ENGINEERING—*W. L. Badger and W. L. McCabe.*

A valuable tool for the refinery and natural gasoline plant engineer, providing a simple approach to the unit operations of chemical engineering. Based on the film concept and unusual classification of unit operations has been adopted. Introduction by Dr. Arthur D. Little. Chapters—General Considerations, Flow of Fluids, Transportation of Fluids, Flow of Heat, Evaporation, General Mechanism of Diffusion Processes, Humidity and Air Conditioning, Drying, Distillation, Gas Absorption, Extraction, Crystallization, Filtration, Mixing, Crushing and Grinding, Size Separation, Conveying and Weighing.

Price $5.00

HANDBOOK OF PETROLEUM ASPHALT AND NATURAL GAS, Revised Edition Bulletin 25, Kansas City Testing Laboratory—*Dr. Roy Cross.*

This well known handbook was revised in 1931 and increased to 865 pages. Material incorporated in the first edition of Bulletin 25 was brought down to date. The following is included: Economics of Gasoline, Transportation Storage and Gaging, Properties of Crude Petroleum, Refining and Cracking of Petroleum, Properties of Refining Petroleum, Fuel Oil, Oil Shale, Asphalt, Natural Gas, Methods of Analysis, Tables, Patents and Publications. Well illustrated by graphs, charts and photographs, and replete with valuable tabulations. . .

Price $7.50

ELEMENTS OF FRACTIONAL DISTILLATION—*Clark Shove Robinson.*

Explains principles of distillation simply and accurately according to best ideas of physical chemistry and chemical engineering. Contents—The Phase Rule, One Component System, Two Component System, More Complex Systems. The Gas Laws, Solutions, Simple Distillation, Fractionation, Rate of Fractionation, Discontinuous Distillation, Design of Continuous Still, The Fractionating Columns, The Condenser, Accessories, Continuous Distillation, Ammonia, Benzolized Wash Oil, Mehyl Alcohol, Ethyl Alcohol.

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